Materials
in Design Engineering

Appliances: what materials are next?

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plus a special 28-page section on THE HIGH TEMPERATURE PROBLEM

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PRICE FIFTY CENTS

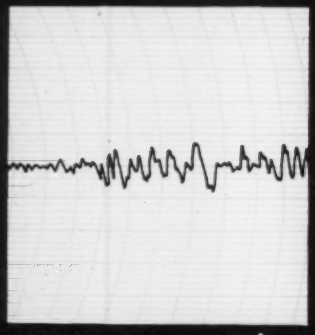
JUNE, 1960

THESE SURFACE TRACES

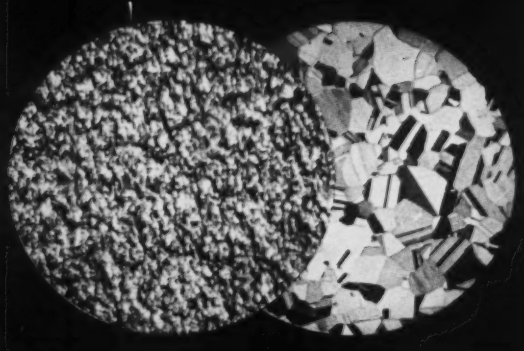
prove that you can cut polishing costs with Formbrite, Anaconda's superfine-grain drawing brass.

STANDARD DRAWING BRASS

(grain size, .045 mm) – after 40% elongation



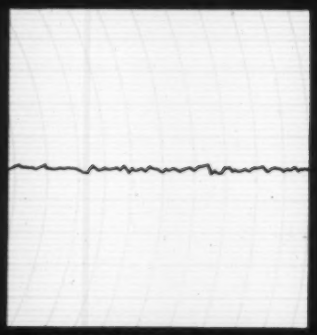
ENLARGED SURFACE TRACE showing the roughness that causes "orange-peel" effect in the working of standard drawing brass. Smoothing such mountains down to the valleys takes considerable cutting. For small deep-drawn products, up to five polishing wheels might be needed. Polishing compound costs run high; production rates, low. Bottlenecks hamstring operations.



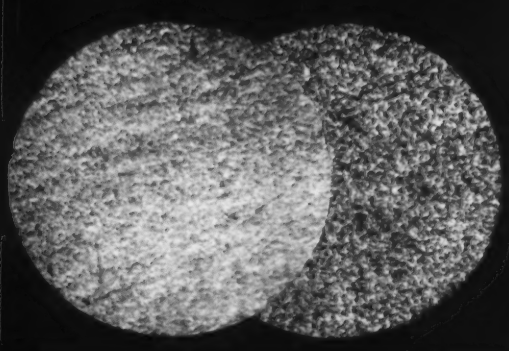
THE STRETCHED SAMPLE of standard drawing brass looks like this (left, above) when seen in oblique illumination and magnified 20x. Its microstructure is shown 75x at right. This is the kind of drawing brass that's been used for decades for stamped or drawn brass products and the micrographs show in another way why polishing costs have been high.

FORMBRITE DRAWING BRASS

(grain size, .005 mm) – after 40% elongation



ENLARGED SURFACE TRACE showing Formbrite's smoothness even after deformation, the test of polishing characteristics of a drawing brass. It is relatively easy to level these little hills on the surface of Formbrite. In many cases, users find they eliminate cutting operations altogether, need only a simple color buff. Finishing savings run up to 50%.



WHEN SEEN IN OBLIQUE ILLUMINATION and magnified 20x by the microscope, the stretched Formbrite surface looks like this (at left, above). Its microstructure is shown 75x at the right. This uniform superfine-grain structure is produced by special procedures of rolling and annealing developed by The American Brass Company.

FORMBRITE is springier, harder, more scratch resistant than the usual drawing brasses in the same standard tempers. Yet it retains remarkable ductility for forming and drawing—even such deep-drawn products as pen barrels. And Formbrite costs no more than ordinary drawing brass, despite its superiority. Get full details from your Anaconda representative or write: The American Brass Company, Waterbury 20, Conn. In Canada: Anaconda American Brass Ltd., New Toronto, Ontario.

6048

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JUNE 1960 | VOL. 51, NO. 6

Materials in Design Engineering

FORMERLY MATERIALS & METHODS

SELECTION & USE OF METALS, NONMETALLICS, FORMS, FINISHES

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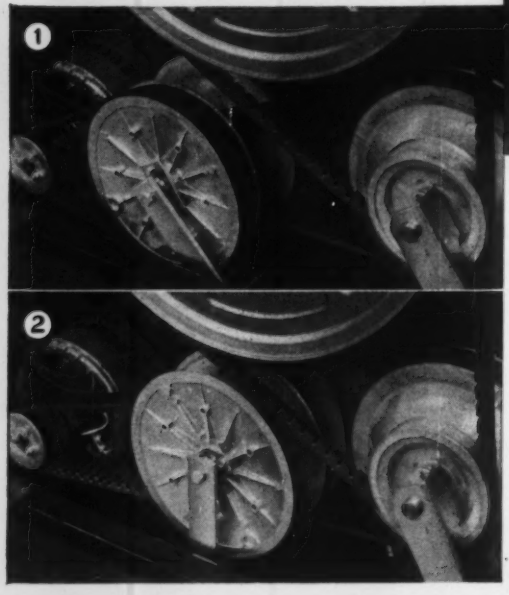
IT'S LIGHTER THAN YOU THINK!

WITH HIGH STRENGTH THIN-WALL SECTIONS

WHEN DIE CAST WITH ZAMAK



A single zinc die casting—a conical disk 7½" in diameter—used in four different positions, makes up this speed changer mechanism for the General Electric Combination Washer-Dryer.

Cast with hub and radial reinforcing ribs and a projection-recess interlocking system (see view above, with one disk cut away to show cross section) two of these parts are pressed, back to back, on a bronze bearing to form a movable drive ratio adjustment. Two single pieces, locked on the ends of the tube, complete the dual-pulley assembly.

In position 1 (at left), the mechanism provides a regulated low speed for washing, rinsing and drying cycles. Moved upright, as in position 2, the drive is changed from an 8 to 1 ratio for centrifuging speeds during the water-extracting cycle.

Zinc die castings, because of their high strength in thin-wall sections, their dimensional accuracy, smooth surface and low cost, are the logical and obvious answer to the problem of producing these heavy-duty appliance parts.

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Properties of Porcelain Enamels
Brazing Alloys for Vacuum Systems
Impregnated Mica Paper — An Excellent Insulator

METAL POWDERS CUT COSTS $1.97 per piece

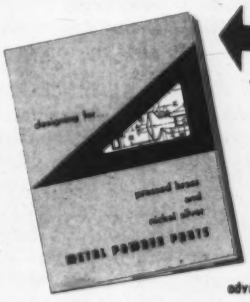
INGENIOUS DESIGN SAVES 95% AND CUTS ASSEMBLY TIME FOR STATOR WINDING AT MINNEAPOLIS-HONEYWELL

Formerly, 13 pieces were machined from brass bar stock and fitted by hand to a plastic ring to provide contact points for this assembly.

TOTAL COST WAS $2.07

CONVERTING TO NICKEL SILVER POWDER, ***ONE PIECE,*** DELIVERED BY THE FABRICATOR* READY FOR ASSEMBLY, IS EMBEDDED IN PLASTIC, THEN CUT BACK TO EXPOSE THE ACCURATELY-PLACED TERMINALS — COST 10¢.

*Sintered Metals, Inc., Boston.



It's New!

"DESIGNING FOR PRESSED BRASS AND NICKEL SILVER METAL POWDER PARTS"

WRITE FOR YOUR COPY — It will give you many valuable suggestions for designing parts to obtain the greatest advantages, including economy, for your products.

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For more information, turn to Reader Service card, circle No. 454

Things happen fast to a rocketing missile. High-nickel Mumetal shields help tape recorders get it all down accurately.

How Nickel helps record messages from space

When a missile rockets off into space, it detects all sorts of data – temperature, radiation, meteoric dust – the many things we need to know in order to conquer space.

Since radio transmission and reception between missile and ground is not always reliable, some missiles carry an airborne secretary–a multi-channeled tape recorder.

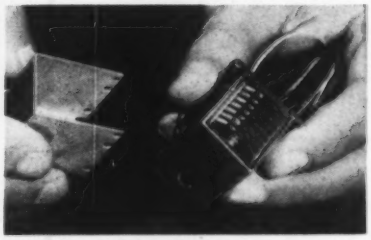
It records as many as thirty different bands of data side by side on a 1½-inch magnetic tape.

Confusion of all the magnetic fields crammed inside the tiny head could cause messages to come out garbled.

But there is a way to keep them straightened out–by using Mumetal* (77% Nickel). This alloy has the unusual ability of soaking up magnetic fields like a sponge. Thin, flat shields of Mumetal siphon off troublesome interference.

The manufacturer also covers the whole head with more Mumetal to bar stray magnetic fields on the outside from getting inside. And then a protective Nickel-chrome plating goes on top of that.

All in all, it's quite a job Nickel does. And something to keep in mind the next time you're faced with a problem in your product or process. If it has to do with high or low temperatures . . . magnetism . . . corrosion . . . fatigue or some other factor, write us. We'd be happy to show you how Nickel, or one of its alloys, may be able to help.



Tiny magnetic head of tape recorder has Mumetal shields to trap magnetic interference, help Davies Lab. Division of Minneapolis-Honeywell pack much in little space. Nickel-chrome plating on cover adds durability, corrosion resistance, and attractive appearance.

*Trademark, Allegheny Ludlum Steel Corporation

The International Nickel Company, Inc.

67 Wall Street INCO New York 5, N. Y.

INCO NICKEL

NICKEL MAKES ALLOYS PERFORM BETTER LONGER

For more information, turn to Reader Service card, circle No. 460

What's new IN MATERIALS

...AT A GLANCE

An extremely dense, low expansion ceramic—a spodumene—has been developed. It has a coefficient of thermal expansion of 5.56×10^{-10} per °F over the temperature range 77-212 F, has high thermal conductivity, does not outgas, and can be fabricated by extruding or slipcasting. The ceramic is designed primarily for use in backward wave oscillator tubes, and as supports for ferrites.
Source: Hughes Aircraft Co., Culver City, Calif.

Titanium metal powder parts being turned out by a new process (details not revealed) are said to be produced at relatively low cost and to close tolerances. According to the developer, the parts have corrosion resistance and strength properties comparable to those of wrought titanium products. The parts are supplied in commercially pure titanium, as well as in titanium alloys. Sizes range from less than a few fractions of an inch to more than 35 sq in. in cross section.
Source: Clevite Corp., Mechanical Research Div., 540 E. 105th St., Cleveland 8.

A new nonwoven fabric construction, now under development, consists of resin-bonded warp and fill yarns. The fabric is made as follows: 1) parallel warp yarns are first laid down, then fill yarns are laid down at a desired angle to the warp; 2) the fill yarns are then resin bonded to the warp yarns on one side only. The warp yarns are individually prestressed as the fabric is made, and the bonded fill yarns hold the warp yarns to the predetermined stress. Consequently, all threads in the fabric are under equal tension.
Source: Coast Mfg. & Supply Co., P. O. Box 71, Livermore, Calif.

A new high temperature vinyl resin, termed a polyvinyl dichloride, offers continuous heat resistance in the 180 to 200 F temperature range, and relatively good strength at these temperatures. Coupled with this heat resistance are the inherent chemical resistance, nonflammability, and toughness of rigid Type I and Type II PVC, according to the developer. Primary market for the material appears to be in industrial and residential plumb-pipe and fixtures. The material can also be plasticized for flexibility. (More details next month.)
Source: B. F. Goodrich Chemical Co., 3135 Euclid Ave., Cleveland.

Three new types of vacuum melted brazing alloys are now commercially available. They are: 1) wide gap alloys that are said to sucessfully bridge joint clearances up to 1/16 in.; 2) general purpose alloys for high temperature brazing; and 3) honeycomb brazing alloys for brazing metal honeycomb assemblies containing thin (0.001 to 0.005 in.) core material.
Source: General Electric Co., Metallurgical Products Dept., Detroit 32.

Closer thickness tolerances for magnesium sheet are now obtainable in AZ31B, HK31A and HM21A alloy sheets up to 48 in. wide. The closer tolerances are one-half of standard tolerances for most thicknesses. For example, the closer tolerance

is ±0.002 in. in 0.050, 0.063, 0.071, 0.080 and 0.090 in. thicknesses, compared to a standard tolerance of ±0.004 in.
Source: Dow Metal Products Co., Div. of Dow Chemical Co., Midland, Mich.

An easy processing, high gloss ABS plastic has been developed. Tests show that the improved material can be injection molded at faster speeds than conventional ABS plsatics, and at approximately the same molding speeds as those used for cellulosics, impact styrenes and polyolefins. The molded parts can be machined, drilled, painted, metallized, cemented and nailed.
Source: Naugatuck Chemical Div., U. S. Rubber Co., 1230 Avenue of the Americas, New York 20.

Tin-coated metals can be produced quickly and easily by using a sponge that is impregnated with tinning metals, chemical cleaners and a flux. When wiped across metal surfaces, the sponge leaves a coating of tin that covers the surface completely and without waste, according to the developer.
Source: Wright Mfg. Co., Cleveland.

A new ductile permanent magnet alloy is said to have high coercive force and energy product values combined with good machinability. The developer says the alloy can be formed into complex shapes which require no costly finishing operations. The material, a copper-nickel-iron alloy, is expected to be used in appliances, speedometers, aircraft instruments, electronic equipment and control systems. It is supplied in the form of magnets, wire and strip.
Source: Hoskins Mfg. Co., 4445 Lawton Ave., Detroit 8.

A clear polyvinylidene chloride coating is said to keep air, oils and grease from passing through paper. The new coating, expected on the market shortly, can be applied by spraying or brushing.
Source: National Starch & Chemical Corp., 268 Madison Ave., New York City.

A new refractory material—tetraboron silicide—is said to have excellent oxidation and thermal shock resistance. Parts made by powder metallurgy techniques have withstood oxidation in air for over 100 hr at 1370 F, and no cracks were observed when the parts were removed from 1370 F to room temperature numerous times. The material is still under development.
Source: E. Colton, Allis-Chalmers Mfg. Co., Research Div., Box 512, Milwaukee 1, Wis.

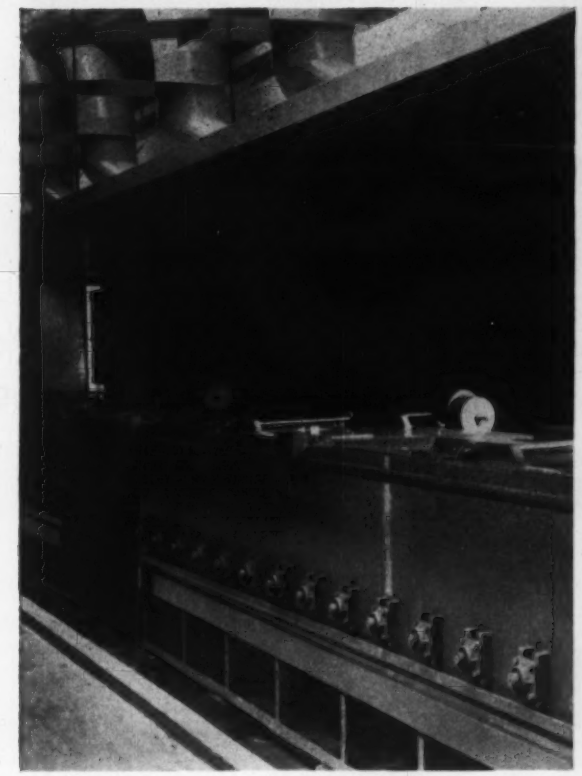
High quality semiconductor devices are being produced by a new process that "combines the best features of currently used alloy and diffusion methods, without their drawbacks." In the new process, alloying and diffusion take place simultaneously. Briefly, a semiconductor device is built up on a piece of p-type germanium; two small metal pellets are then placed on the germanium and the assembly is heated. The germanium dissolves into the metal pellets until saturation is reached, and the pellet impurities diffuse into the solid germanium.
Source: Amperex Electronic Corp., 230 Duffy Ave., Hicksville, N. Y.

Low cost glass pillows and balls are now available for filler, filter and packing applications. The hollow pillows are said to provide a low density filler material for such applications as packing in aircraft wings where the glass gives both structural support and buoyancy.
Source: Corning Glass Works, Corning, N. Y.

Turn to page 9 for more "What's New in Materials"

Another new development using

B.F.Goodrich Chemical *raw materials*



Complete acid etching machine of rigid Geon was developed by Industrial Plastic Fabricators, Inc., Norwood, Massachusetts. It is used by Corning Electronic Components, Corning Glass Works, Bradford, Pennsylvania, to produce Fotoform and FOTOCERAM® products like the circuit board shown. B.F.Goodrich Chemical Company supplies the rigid Geon vinyl.

Machine of rigid Geon produces low cost precision etching on glass

"Chemical machining" is the accurate term for the high precision etching on glass done by this new machine. Square-cornered, submicroscopic holes can be produced with small tolerances and close center-to-center distances. Or a precise pattern can be created in glass, whether it involves holes, cut-outs, or channels. Screens with mesh as fine as 560,000 holes per square inch have been produced.

The machine is made of shapes, sheets and rods made of Geon rigid vinyl. Geon is unaffected by the acids that do the etching job. It provides the durability and impact strength needed for fabrication. And it is as easy to handle as any material used for manufacturing.

Here's another example of the way Geon vinyl can open new markets or improve old applications. For more facts, write Department GV-3, B.F. Goodrich Chemical Company, 3135 Euclid Avenue, Cleveland 15, Ohio. Cable address: Goodchemco. In Canada: Kitchener, Ontario.

Geon VINYLS

B.F.Goodrich Chemical Company

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B.F.Goodrich *industrial cellular materials*

For more information, turn to Reader Service card, circle No. 351

Nickel Alloy Stands Up to Severe Corrosive Conditions

New data show complex alloy is useful in wide range of oxidizing and reducing solutions

■ A complex nickel alloy called Ni-o-nel can be exposed to a great variety of corrosive solutions, some of unusual severity, recently completed tests show.

Extensive corrosion data were made available recently by International Nickel Co., Inc., 67 Wall St., New York, which developed the alloy about three years ago. The information is summarized below and in the accompanying table.

Composition, properties: Nominal composition of the alloy is: Ni, 42%; Cr, 21.5%; Mo, 3%; Cu 2.25%; plus manganese, silicon, carbon, titanium and iron. The material is normally furnished to users in the mill annealed condition. Mechanical properties in this condition are: yield strength (0.2% offset), 35-60,000 psi; tensile strength, 85-105,000 psi; elongation (in 2 in.), 35-50%; hardness, 75 90 Rockwell B.

Corrosion resistance: The relatively high nickel content of the alloy, in addition to the chromium, copper and molybdenum present, makes it considerably more resistant to reducing conditions, such as found in sulfuric or phosphoric acid solutions, than most of the common stainless steels. The chromium-plus-nickel content makes the alloy resistant to a variety of oxidizing chemicals such as nitric acid solutions, nitrates, and cupric, ferric and mercuric salts except chlorides. With a combined resistance to oxidizing and reducing corrosive solutions, Ni-o-nel can be applied where a broad range of corrosive conditions will be encountered. The table presents some plant corrosion test results.

RESULTS OF NI-O-NEL PLANT CORROSION TESTS

Test Solutions	Temp, F	Duration of Test, days	Corrosion Rate, ipy
Aqueous solution containing 0.5% sulfuric acid	210	45	0.002
25-50 gm/l H_2SO_4, 25-100 gm/l $MnSO_4$, 1-3 gm/l $Fe_2(SO_4)_3$. Immersed in sump in MnO_2 electrolysis circuit. Flow 100 gpm	200	119	0.0028
100-200 gm/l H_2SO_4, 40-100 gm/l selenious acid, small amount sulfurous acid	70–80	90	Nil
78% sulfuric acid with traces of benzene sulfonic acid in bottom of acid settling tank	100–130	56	0.0005
Slurry in digester tank containing 20% H_3PO_4, 2% H_2SO_4, 1% HF, 40% H_2O, plus Ca_2SO_4	170–200	117	0.0007
Evaporator heated with hot gases in acid containing 53% H_3PO_4, 1-2% H_2SO_4, 1.5% HF plus Na_2SiF_6	250	42	0.006
Evaporator during concentration of nitric acid solution from 35-45% nitric acid, saturated with zirconyl nitrate and containing 10-35% $ZrO(NO_3)_2$ crystals			
In liquid	235–255	29	0.021
In vapor	235–255	29	0.026
Vapor during concentration of nitric acid solution containing 35-45% nitric acid, 3-20% chlorine as chlorides, and 10-20% metal nitrates (mainly zirconium)			
Liquid	240–260	21	0.013
Vapor	240–260	21	0.0058
Mixture of 96.5-98% acetic acid, 1.5% formic acid, 1-1.5% water	255	262	0.006
Mixture of 40% acetic acid, 6% propionic acid, 20% butane, 5% pentane, 8% ethyl acetate, 5% methyl ethyl ketone, plus other esters and ketones	345	217	0.002

Effects of specific environments: a summary

Sulfuric acid: Ni o-nel should have useful resistance in sulfuric acid solutions up to about 40% concentration at boiling temperature, up to 60% at 176 F, and in all concentrations up to about 150 F.

Sulfurous acid: Useful resistance to wet sulfur dioxide and to many sulfurous acid solutions, particularly if they contain significant amounts of sulfuric acid.

Phosphoric acid: Useful resistance to pure phosphoric acid solutions at all concentrations and temperatures up to and including boiling 85% phosphoric acid.

Nitric acid: Useful resistance to all concentrations and temperatures up to and including boiling 65% nitric acid. Although the alloy would ordinarily show no advantage over one or more of the austenitic stainless steels in pure nitric acid solutions, it will provide superior service in mixtures of nitric with other acids such as sulfuric or phosphoric, or where small amounts of chlorides or fluorides are present.

Organic acids: High resistance to most of the organic acids in-

cluding boiling concentrated acetic acid, acetic-formic acid mixtures, and maleic and phthalic acids.

Sea water: Considerably more resistance to pitting and crevice attack after biological fouling than most of the common stainless steels.

Miscellaneous: Ni-o-nel is highly resistant to most alkali solutions although its resistance to hot concentrated sodium hydroxide and potassium hydroxide is usually not as good as that of nickel. Ammonia and ammonium hydroxide solutions do not attack the alloy under most conditions of application.

The alloy is not resistant to hydrochloric acid solutions except in very dilute concentrations. This is also true when wet chlorine or hypochlorite solutions are the corrodents.

For more information, circle No. 600

***Ductile wire** ranging from 8 to 50 mils in dia has been made from new alloys.*

Less Costly Resistance Alloys for 2000 F

New iron-base alloys combine high resistivity with high oxidation resistance

by W. L. Horigan and William Feduska,
Materials Engineering Dept., Westinghouse Electric Corp.

■ Encouraging results have been obtained with a new class of iron-base electrical resistance alloys now under development. Preliminary results indicate that the alloys, called Hirox, will be inexpensive and will combine very high electrical resistivity with

high resistance to oxidation at temperatures over 2000 F. However, additional development on joining methods and pilot plant production is needed before they are made commercially available.

Composition is important

Because of their high iron content the new alloys are expected to be less expensive than most premium-grade materials now in use. Their composition depends on the physical and mechanical properties needed. Present composition limits are: 6 to 10% aluminum, 3 to 9% chromium and 0 to 4% manganese. Minor additions of zirconium and boron are used.

Electrical resistivity and oxidation resistance of the alloys increase with aluminum and chromium content up to the limits indicated. If aluminum content is increased beyond 10%, an ordered structure is formed that greatly reduces ductility and workability, without adding to electrical and oxidation resistance. Similarly, chromium content above 9% would not increase resistivity appreciably, but would increase the possibility of sigma phase embrittlement during long-time service at intermediate temperatures.

Tests have shown that in the composition range desired iron and aluminum tend to form large grains in the cast ingot or during heating for working. These large grains have low ductility and tend to crack during working. However, such effects can be minimized by adding zirconium and boron. These two elements combine in the melt to form nucleation sites that refine the cast structure, as well as acting to inhibit grain growth during working at elevated temperatures.

TABLE 1—PROPERTIES OF A TYPICAL HIROX ALLOY*

Ult Ten Str, psi	
Room Temp	118,850
1300 F	15,000
Yield Str (0.2%), psi	
Room Temp	111,650
1300 F	14,950
Elongation, %	
Room Temp	15
1300 F	94
Reduction of Area, %	
Room Temp	42
1300 F	98
Specific Gravity	6.94
Elec Resistivity, Room Temp, ohm/cir mil-ft	
10-Mil Dia Wire	845
20-Mil Thick Strip	851

*9% aluminum, 9% chromium, balance iron, with minor additions of zirconium and boron.

Typical properties

Important mechanical and physical properties of a typical Hirox alloy are shown in Table 1. The Hirox alloys have high resistivity and appear suitable for use up to 2300 F because of their high oxidation resistance. Table 2 shows how the alloys compare in oxidation resistance with the popular 80:20 nickel-chromium alloy. In other tests a 10-mil thick Hirox wire was operated in air at 2350 F for 50 hr before failure occurred.

How they are made

Although some experiments have been made with air melting, best quality is obtained by vacuum melting the Hirox alloys. The alloys can be processed by normal forging, rolling and wire drawing techniques. In general, working is done below the recrystallization temperature (about 1200 F). Working may be followed by a stress relief anneal to impart greater room temperature ductility for forming operations such as wire drawing and cooling. Wire sizes drawn to date range from 8 to 50 mils in dia.

Considerable development work remains to be done on joining the alloys. Mechanical joints operate satisfactorily, and good joints can be made by brazing under carefully controlled conditions. However, iron-base electrical resistance alloys are not normally amenable to joining by fusion welding if they contain aluminum.

TABLE 2—OXYGEN PICKUP OF THREE RESISTANCE ALLOYS AT 2000 F*

Alloy ↓	No. of Cycles	Oxygen Pickup, oz/sq in.
9 Al-9 Cr	872	0.00139
5 Al-25 Cr	900	0.00202
80 Ni-20 Cr	900	0.1003

*After intermittent cycling consisting of 6½ min heating, 1½ min holding time, and 7½ min cooling.

For more information, circle No. 601

Low Melting Glasses Liquid at Room Temperature

■ Glasses that melt at room temperature and below are among a new series of inorganic glass compositions developed by Bell Telephone Laboratories, 463 West St., New York 14. Described by A. D. Pearson and W. R. Northover at the recent annual meeting of the American Ceramic Society, the glasses are composed of arsenic, sulfur and bromine. They are developmental and not yet commercially available.

The new ternary compositions are glassy solids at temperatures below their softening point, show conchoidal fracture like that of typical silicate glasses, and exhibit no extensive ordering in their structure. Several of these glasses are as fluid as glycerin at room temperature.

Range of properties

A wide range of softening points and chemical compositions can be achieved. For example, up to 20% bromine can be used without lowering the softening temperature. Greater amounts of bromine lower softening and fluidity temperatures to room temperature and below.

The new compositions appear to have properties similar to those of the older low-temperature-softening glasses, e.g., arsenic-sulfur (or selenium)-thallium composi-

tions, and the arsenic-sulfur (or selenium) - iodine compositions. They are relatively stable in acids, but are attacked by alkalis. They tend to hydrolyze in water, this tendency increasing as softening points are lowered. The solid glasses show good volume resistivities, with values as high as 10^{15} ohm-cm. Resistivities of the compositions in liquid form are about 10^{8} ohm-cm.

Optically, the glasses are all transparent, ranging in color from ruby red to light amber. Indexes of refraction appear to range between 1.9 and 2.0—comparatively high values for glasses.

For more information, circle No. 602

Strong Silicon Bronze Has High Electrical Conductivity

Nickel-silicon alloy offers advantages over conventional 2% and 3% silicon bronzes

■ A new bronze recently announced by Bridgeport Brass Co., Bridgeport, Conn. has a nominal composition of 97.5% copper, 1.9% nickel, and 0.6% silicon. In the ordinary hard drawn state, its ductility equals that of 2% silicon bronze and is superior to that of 3% silicon bronze. After precipitation hardening it has higher yield strength than either (see table). Yield strength also exceeds that of aluminum alloys and low carbon steels.

Combined with these favorable mechanical properties is an electrical conductivity about four times that of other silicon bronzes.

Applications are foreseen in the electrical manufacturing industry where high strength, electrical conductivity and corrosion resistance are important factors. Some of the items now being made are pole line hardware, switchgear components and wire connectors. Other parts said to benefit from the properties of the new bronze are: bolts, studs, U-bolts, cold formed nuts, nails, screws, pipe clamps and hangers, swivel joints, and marine hardware.

Called Nironze 635, the bronze is currently available only as round rod and wire. Bar diameters range from 0.062 in. to 1.5 in. and coil diameters from 0.062 to 0.625 in. Other shapes and sizes are available on special order.

Material is normally shipped from the mill in the solution treated and cold worked condition. Aging by the fabricator is required to develop the superior mechanical properties and electrical conductivity. The alloy can be obtained from the mill in the aged condition but this is not recommended if the material will be cold worked during the fabrication process.

For more information, circle No. 603

COMPARISON OF NIRONZE 635 AND STANDARD SILICON BRONZES

Property →	Physical		Fabrication			Mechanical		
	Elec Cond (annealed), % IACS	Density, lb/cu in.	Cold Workability	Machinability Rating, %	Annealing Temp, F	Ten Str, 1000 psi	Yld Str, 1000 psi	Hardness, Rockwell B
Nironze 635[a]	**30**	**0.320**	**Excellent**	**30**	**850–900[b]**	**100**	**85**	**95**
High Silicon Bronze (3%)	7	0.308	Excellent	30	900–1300	108	60	95
Low Silicon Bronze (2%)	9	0.316	Excellent	30	900–1250	90	67	90

[a]Drawn and aged. [b]Aging temperature.

MORE WHAT'S NEW IN MATERIALS

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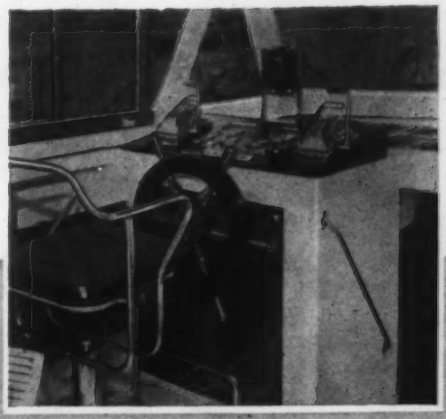
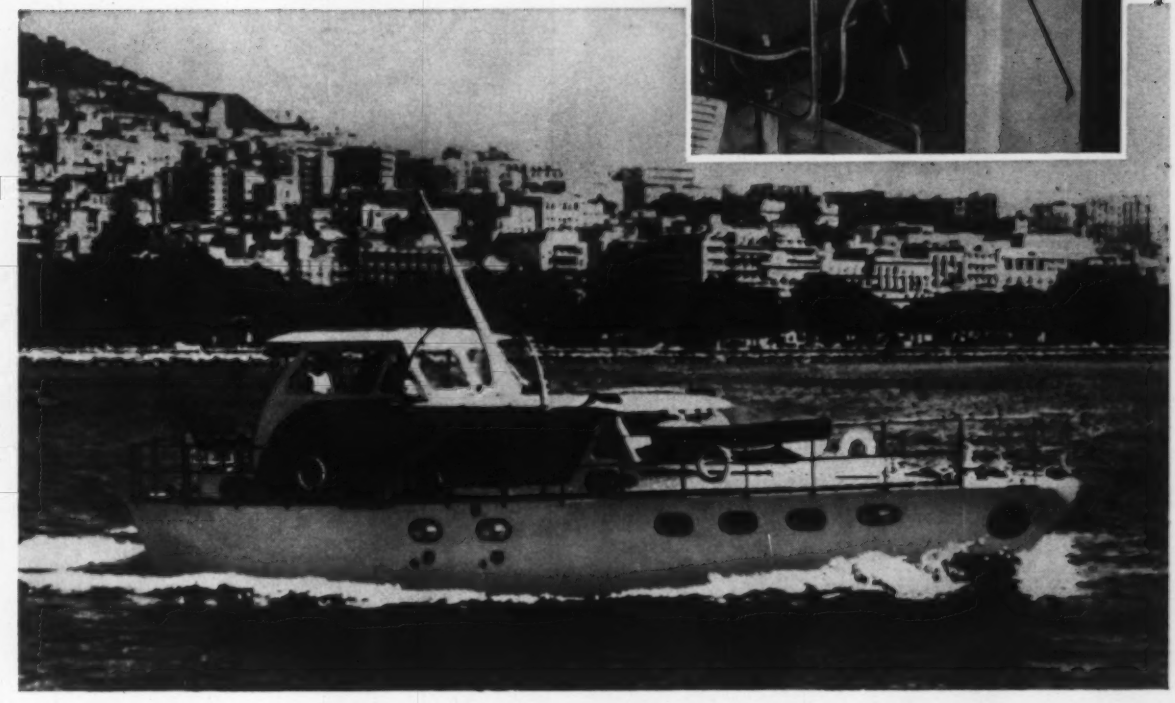
RCI POLYLITE RESINS





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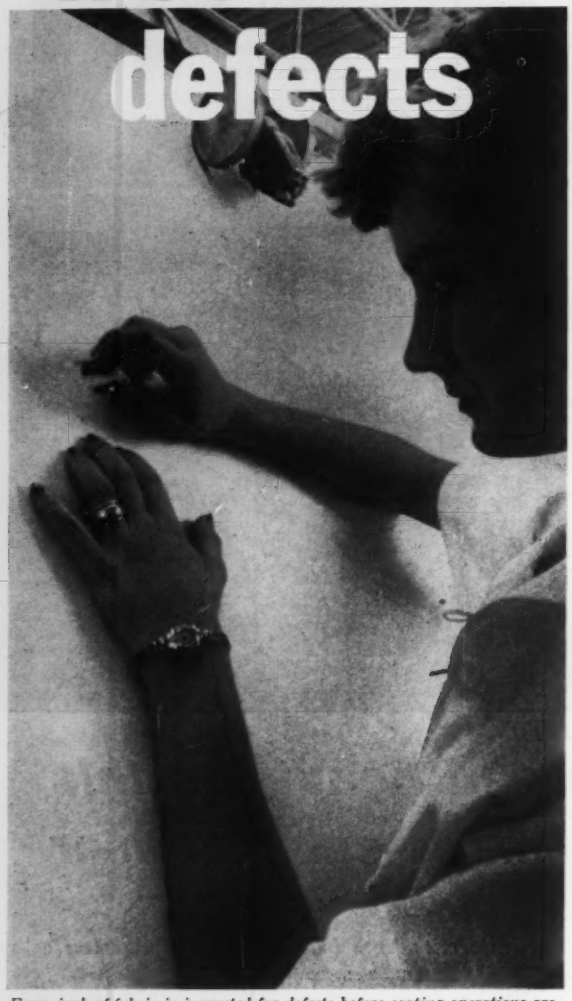

Every inch of fabric is inspected for defects before coating operations are begun. Here the operator is shown removing slubs.

Close up of a weaving imperfection being removed by burling.

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For more information, turn to Reader Service card, circle No. 335

Ductility of ceramics

To the Editor:

In reviewing the article "New Developments in Ceramics" (M/DE, May '58, p 121) I note that elongation and ductility characteristics of ceramics were carefully omitted.

These properties are of primary importance in any mechanical design. Also important is tensile strength as contrasted to flexural strength. Actually, flexural properties are of no real value to a mechanical designer. Yet some chemists (as illustrated by some plastics industry personnel) insist on using this confusing and unusable design property. This accounts for the fact that nonmetallic materials have enjoyed limited success in mechanical fields.

Could you advise where elongation, ductility and true tensile properties for ceramics might be found?

C. F. MARSCHNER
804 Wisteria Dr.
Marietta, Ga.

Elongation and ductility are never given for ceramic materials because essentially they have none. Impact strength values seem to be the only way to indicate any degree of ductility in a ceramic material.

Help needed on . . . laminating polyethylene

To the Editor:

I would like to obtain information on laminating polyethylene sheeting.

E. L. SOLOMON
1352 N. Miami Ave.
Miami, Fla.

Polyethylene is usually applied to paper, paper board and other materials as a hot melt coating because difficulty is encountered with adhesives. For specific information, we suggest contacting some of the major polyethylene producers.

. . . heat, alkali resistant elastomer

To the Editor:

I am looking for an elastomer that can be used in reducing atmospheres and in aqueous and molten alkali hydroxides at temperatures from 120 to 840 F. I will accept a temperature range of 120 to 660 F as a bare minimum.

What about inorganic elastomers? Have any of them come on the market?

SHELDON KRIZER
Patterson Moos Research Div.
Leesona Corp.
90-28 Van Wyck Expressway
Jamaica 18, N. Y.

At present a great deal of research is being carried

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out at various locations in an attempt to develop a stable inorganic elastomer. Some limited success has been obtained, but certainly far from enough for even semi-commercial sampling.

. . . destruction of materials by heat

To the Editor:

I would like to obtain information or tables showing the temperatures at which various materials fuse and are destroyed by heat . . .

E. J. FISHER
Professional Engineer
2727 Irving Park Rd.
Chicago 18

We suggest contacting Wright Air Development Center, Wright-Patterson Air Force Base, Ohio.

. . . porous material for milk

To the Editor:

During a recent exhibit of the North Dakota Inventors Congress, a friend asked me if I knew of a material with a porosity that would retain milk but release air. He has some such material in mind for the manufacture of nursing bottles for infants.

MARION B. RICHARDSON
Professor and Chairman
School of Engineering
North Dakota State College
Fargo, N. D.

Sorry, but we haven't been able to come up with an answer. Maybe some of our readers can solve the problem.

Ultrasonic welding

To the Editor:

Your article "The New Welding Processes" (M/DE, Jan '60, p 105) has been received with a great deal of interest. We are particularly interested in ultrasonic welding as we think it might be a good method for hermetically sealing two pieces of 0.001-in. thick commercially pure titanium together.

Would you advise us of the names and addresses of firms that are currently producing ultrasonic welding equipment or firms that are actively soliciting ultrasonic welding work to do in their own shops.

W. R. HAGAN
Vice President
John J. Foster Mfg. Co.
Costa Mesa, Calif.

We suggest contacting Aeroprojects, Inc., West Chester, Pa., Gulton Industries, Inc., Metuchen, N. J., or Westinghouse Electric Corp., East Pittsburgh, Pa.

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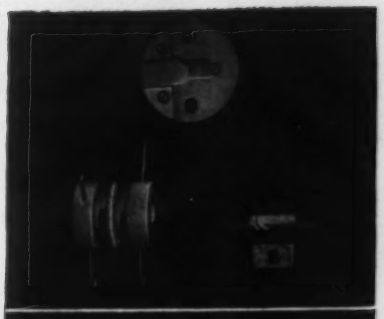

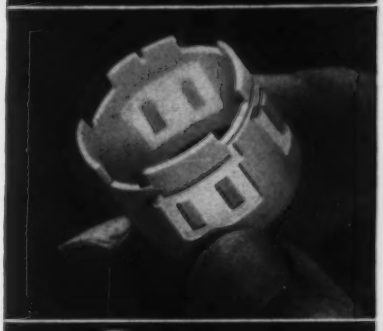

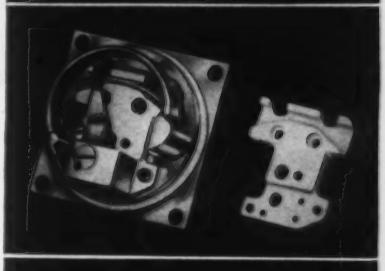

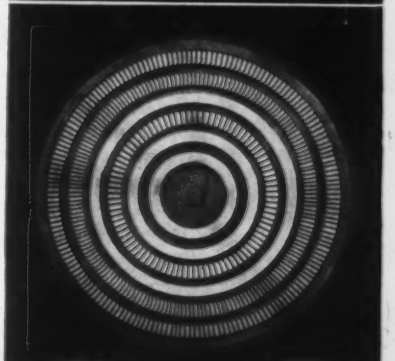

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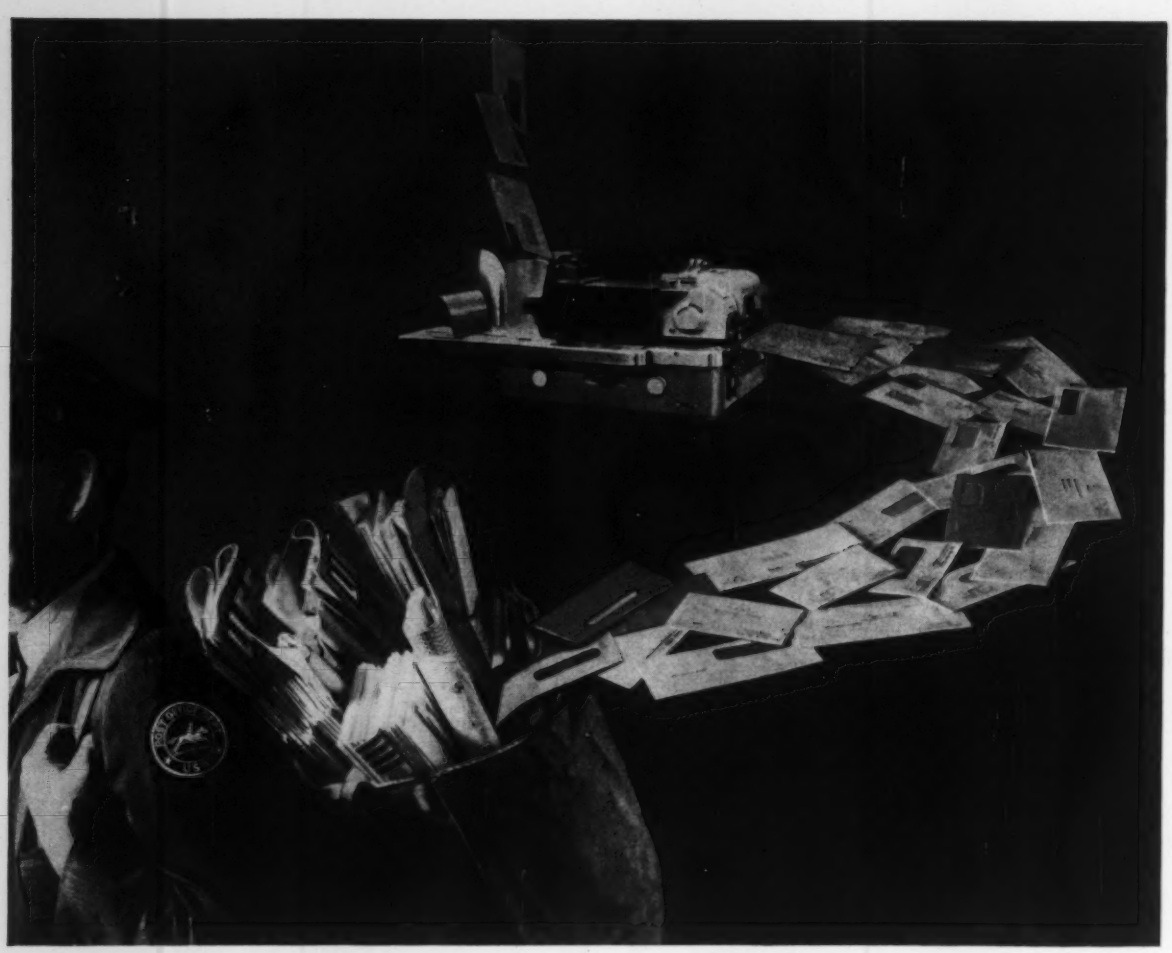

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...AT A GLANCE

A 50% boost in beryllium production was announced recently by Brush Beryllium Co. Capacity of the firm's Elmore, Ohio plant will be increased to 24,000 lb of vacuum cast beryllium billets per month from the present 12,500 lb per month.

Price of a relatively new emulsion used in adhesives has been cut by Shawinigan Resins Corp. New price of Resin D-243 (a borax stable polyvinyl acetate-dibutyl maleate copolymer emulsion) is now 20¾¢ per lb in carload lots, down 1½¢ per lb from the previous price. The producer says the emulsion ". . . has demonstrated excellent adhesion to many difficult surfaces."

Price cuts on some copper sheets have been announced by Revere Copper & Brass Inc. Prices for 16 oz copper sheets in 30 and 36 in. widths and 96 to 120 in. lengths have been reduced to meet imported copper sheet prices. Current price of imported 16 oz copper sheets is approximately 50¢ per lb. Revere says it is prepared to remain competitive and its prices will fluctuate to match prevailing import prices. Other domestic brass firms have also cut their prices on several sizes of 16 oz copper sheet. Imports of all brass mill products totaled 200 million lb in 1959, up from the previous record of about 154 million lb in 1958.

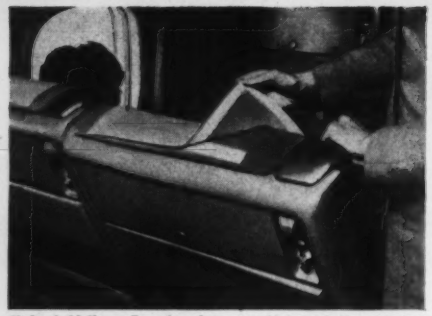
A new supplier of polyethylene will be Foster Grant Co., Inc. The company says it will build a multi-million dollar plant utilizing a high pressure polymerization technique. Meanwhile, Dow Chemical Co. announced that it has begun production of polyethylene film. The material, trademarked Polyfilm, is produced in thicknesses from ½ to 10 mils in a variety of widths.

A 75% price reduction on a relatively new Freon gas has been announced by Du Pont. The gas, called Freon-C318 octafluorocyclobutane, is available in container sizes up to one ton at prices varying from $6.65 per lb in 14 lb cylinders to $4.84 per lb in 2200 lb tanks. The gas formerly sold for $20 per lb. Most important present use for the material is as a dielectric gas.

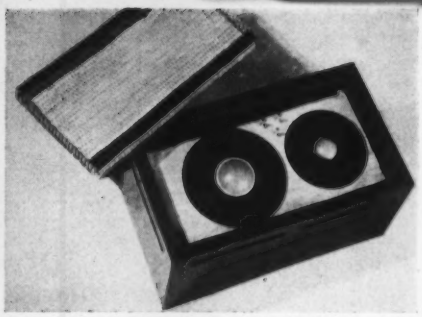
Plenty of tellurium is available for thermoelectric use, say U. S. and Canadian producers in a recent statement designed to counteract rumors of an impending shortage. The producers estimate that annual production of tellurium can be raised to 500,000 to 750,000 lb per year using only present sources. Until now the metal was only available in limited quantities.

More polypropylene will be available as a result of Humble Oil Co.'s new 40-million-lb-per-year plant in Baytown, Tex. The polypropylene, called Escon, is made by a continuous process in three melt indexes. It is sold through Enjay Co. Five other companies besides Humble are producing or are about to produce varying amounts of the new plastic (see M/DE, Aug '59, p 19).

REVOLUTIONARY FASTENER IDEAS FROM CURRENT VELCRO APPLICATIONS



United Airlines Douglas Jets use Velcro fasteners for removable headrest covers; cut servicing time in half. Velcro is also used by Boeing, Convair, Lockheed.



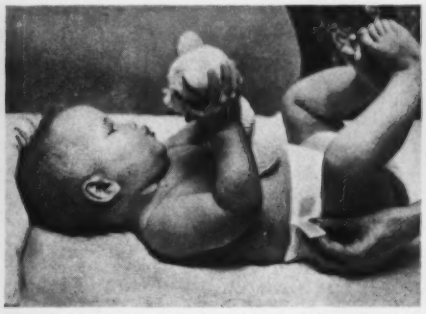
Acoustic Research fastens new hi-fi speaker grilles with Velcro. Speeds assembly; assures secure, continuous closure. Velcro makes service inspection easier.

Skyway Luggage speeds packing, helps prevent shifting and wrinkling with Velcro-fastened "suit-tree". Velcro fastener adjusts to varying bulk of clothing.

Union Carbide attaches carpet over access panels (and in elevators) with Velcro. Carpets lay flat, won't shift, may be removed and replaced quickly, easily.

U. S. Rubber uses Velcro for easy, speedy, invisible closures on bad-weather boots. Velcro is also used as the fastener on safety clothing in many plants.

The Lamports Company uses Velcro to fasten filter media. They are easily changed, speed production and cut costs in chemical and other processing plants.



Riegel Velcro-tabbed diapers eliminate safety pins, are safe, comfortable, and adjustable. Washable Velcro is approved by the American Institute of Laundering.

Taylor Instrument, W. A. Baum, David Clark secure blood pressure cuffs and other medical and surgical equipment with Velcro. Velcro fastens faster, easier.

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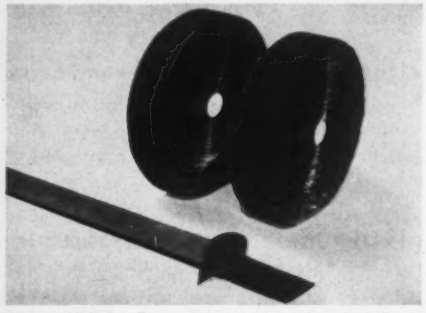

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All-British Show

The first comprehensive all-British exhibition ever held in the United States is scheduled for June 10-26 at the New York Coliseum.

The Show, sponsored by the British-American Chamber of Commerce in New York, the Dollar Exports Council and Britain's Board of Trade, will concentrate on "a wide range of commercial and industrial products."

Of special interest will be displays of experimental steam turbines; peacetime uses of atomic energy, especially in aircraft; and new materials.

Plastics Institute of America May Soon Be a Reality

Firm plans for a Plastics Institute of America (PIA) have finally emerged from the controversy and false starts of the past few years.

The Plastics Institute, patterned somewhat after the Textile Research Institute, will be an independent, industry-supported research, educational and information center loosely affiliated with a university or college (as yet unselected). It will provide a central facility for plastics research, education and information.

Purpose of the proposed Institute was recently outlined by Professor Louis F. Rahm, of Princeton University, who is chairman of the Plastics Institute Committee. This Committee, made up of representatives of all segments of the plastics industry, has already worked out the details of organization, financial support and initial direction. Industry support and advice will be sought later this month.

Three-pronged approach

The three major objectives of PIA are:

1. *Research*—Both basic and applied, involving studies of the fundamental nature and behavior of plastics materials, and problems related to their conversion and use in end-products. Work will be in the form of both a general program and group-sponsored research.

The general program will be aimed at generating information in areas of basic and applied technology where information is clearly lacking. Support for this work will be provided by corporate membership dues and fellowship grants.

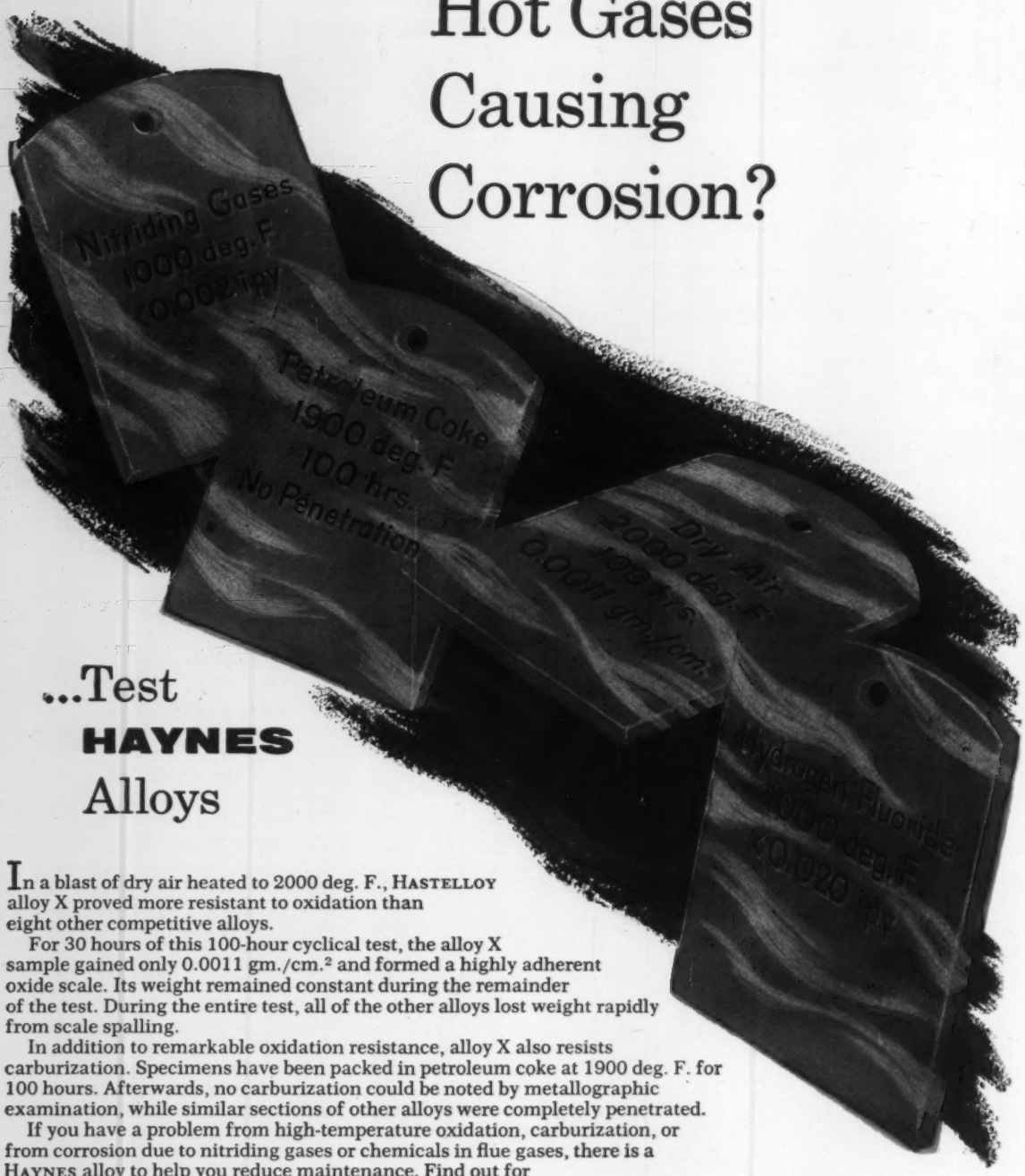
Group-sponsored research will be carried out on projects specifically supported by corporations, governmental agencies and other groups.

2. *Education* — Although PIA will not directly affect the policies of the educational institute with which it is affiliated, it will provide a facility for graduate level work in polymer science and plas-

Silver brazing training course—A packaged, self-study training course in the principles and techniques of silver alloy brazing has been developed by Handy & Harman, Inc. The course, priced at $25, contains three textbooks and all necessary parts, brazing alloys, fluxes and other supplies. The course consists of three sections: 1) six lessons on fundamentals of silver brazing; 2) nine exercises to be performed on basic types of joints in both flat and tubular members, using similar and dissimilar metals; and 3) discussions of such problems as alloy selection, design for assembly and replacement, preform development, preparation of parts, and heating methods and equipment.

For more information, circle No. 479

Hot Gases Causing Corrosion?



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We'll gladly send you samples. But to make sure we send you the alloy or alloys most nearly suited to your need, we ask that you send a letter outlining your own particular conditions. If you would like to learn more about alloy X, ask for a copy of the booklet, "HASTELLOY Alloy X."

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tics engineering. This is expected to provide an increased number of available research personnel for PIA as well as highly qualified, trained personnel for industry.

3. *Information source* — PIA will establish and maintain a comprehensive technical library and information service on plastics technology. This service will provide a source of information on work being done in PIA as well as integrate current technical literature on plastics.

Individuals indicating support and enthusiasm for the Institute include J. W. LaBelle, Foster Grant Co., Inc.; J. H. Du Bois, Tech-Art Plastics Co.; A. A. Hutchings, F. J. Stokes Corp.; R. L. Mondano, Raytheon Co.; S. E. Q. Ashley, Major Appliance Laboratories, General Electric Co.; and Dr. G. Kline, National Bureau of Standards.

Engineering Education

The impact of new technologies and other factors affecting changes in engineering education will be discussed at the 68th annual meeting of the American Society for Engineering Education set for June 20-24 at Purdue University.

Among the major topics to be covered are: long range education and development of the engineer, the impact of new technologies, recruitment and development of engineering faculties, high school preparation for college, the new role of mathematics in engineering, a report on cooperative education, the national survey of technical institute education, and ASEE's role in Latin American relations.

A special event will be a "Workshop on Solid State Electronics."

ASTM to Cover Materials Science, Strength of Materials, Solar Energy

An analysis of the present state of materials science and a symposium on the nature and origin of strength of materials will highlight the American Society for Testing Materials annual meeting scheduled for June 26-July 1 at Chalfonte-Haddon Hall, Atlantic City.

Materials science

The symposium on materials science will be conducted by the Society's new Div. of Materials Science and will consist of four papers: Accomplishments and Limitations of Solid State Theory; The Influence of Surfaces on the Properties of Materials; Mechanical Properties of Semiconductors; and Status of Ductile Ceramic Research.

The symposium on strength of materials will include five papers: Dislocation Motions and the Yield Strength of Solids; Fatigue Strength of Solids; Resistance to Creep Deformation and Fracture in Metals and Alloys; Brittle Fracture and the Strength of Metals; and Size and Shape Effects on Fracture of Solids.

Other technical sessions

In addition to the two special symposia, the annual five-day meeting will include about 35 to 40 technical sessions on such things as fatigue, steel, nonferrous metals, high temperatures, general testing, and low temperature properties of high strength materials.

Some 800 to 900 technical committees and subcommittees of the Society have planned meetings that week. There will also be a special exhibit of testing and scientific apparatus and laboratory supplies.

Special lectures

▸ *Marburg Lecture*—Dr. Farrington Daniels, vice president of the National Academy of Sciences and professor emeritus of the University of Wisconsin, will discuss the utilization of solar energy. Specifically, Dr. Daniels will review solar energy research, emphasizing particularly the new materials that are necessary for the successful use of solar energy.

New materials to be covered include: plastics for reflectors and covers of solar collectors, silicon in solar cells, solid state devices for thermoelectric and thermionic energy converters, and coatings for high efficiency energy absorbers.

▸ *Gillett Lecture* — This lecture, jointly sponsored by ASTM and Battelle Memorial Inst., will be devoted to nuclear fuel elements. Dr. Carson Dalzell, assistant to the director of the Div. of Reactor Development, Atomic Energy Commission, will outline the important scientific problems and the engineering and economic considerations faced by designers specifying nuclear fuel elements.

Ceramics May Solve Space Age Materials Problem

Ceramics may be the only solution left to space age materials problems, according to Dr. John R. Townsend, special assistant to the Director of Defense Research and Engineering.

According to Dr. Townsend, "We are rapidly reaching the

(continued on p 184)

Coming Meetings on next page; more News on p 184

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News OF INDUSTRY

Coming Meetings

AMERICAN NUCLEAR SOCIETY, 6th annual meeting. Chicago. June 12-16.

1ST INTERNATIONAL POWDER METALLURGY CONFERENCE, Metal Powder Industries Federation; and Institute of Metals Div., Metallurgical Society of AIME. New York City. June 13-15.

ALLOY CASTING INSTITUTE, annual meeting. Hot Springs, Va. June 19-21.

APPLIED MECHANICS CONFERENCE, American Society of Mechanical Engineers, Penn State University, University Park, Pa. June 20-22.

DROP FORGING ASSN., annual meeting. Seignory Club, Quebec. June 26-29.

AMERICAN SOCIETY FOR TESTING MATERIALS, 63rd annual meeting and exhibit. Atlantic City. June 26-July 1.

NATIONAL TOOL & DIE MFRS. ASSN., summer meeting. Banff, Alta. July 2-6.

NATIONAL ASSN. OF METAL FINISHERS, annual meeting. Los Angeles. July 22-24.

AMERICAN ELECTROPLATERS' SOCIETY, annual meeting. Los Angeles. July 24-28.

SOCIETY OF AUTOMOTIVE ENGINEERS, INC., national West Coast meeting. San Francisco. Aug 16-19.

PRODUCTION ENGINEERING SHOW, Chicago. Sept 6-16.

MACHINE TOOL EXPOSITION, National Machine Tool Builders' Assn. Chicago. Sept 6-16.

ELECTRONIC INDUSTRIES ASSN., fall meeting. French Lick, Ind. Sept 13-16.

AMERICAN DIE CASTING INSTITUTE, annual meeting. Chicago. Sept. 14-15.

STEEL FOUNDERS' SOCIETY OF AMERICA, 58th fall meeting. Hot Springs, Va. Sept 18-20.

POWER CONFERENCE, American Society of Mechanical Engineers and American Institute of Electrical Engineers. Philadelphia. Sept 21-23.

NATIONAL FOUNDRY ASSN., annual meeting. Chicago. Sept 22-23.

15TH ANNUAL INSTRUMENT-AUTOMATION CONFERENCE AND EXHIBIT, Instrument Society of America. New York City. Sept 26-30.

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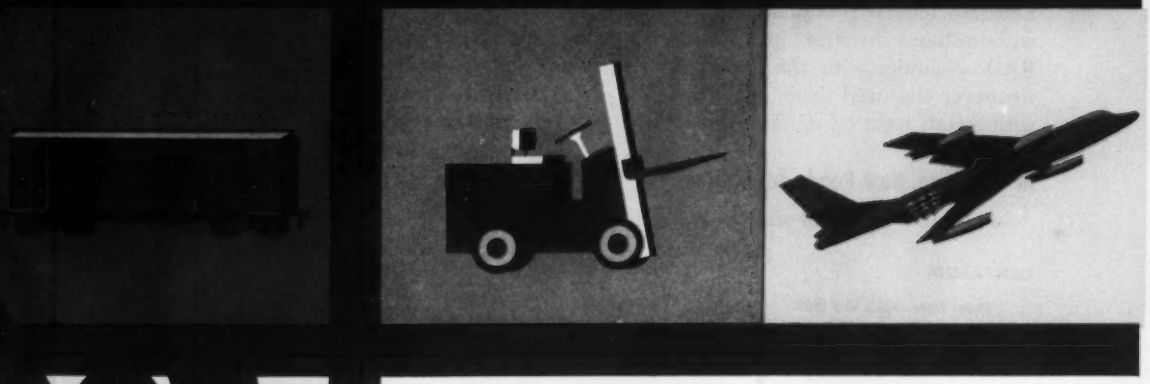
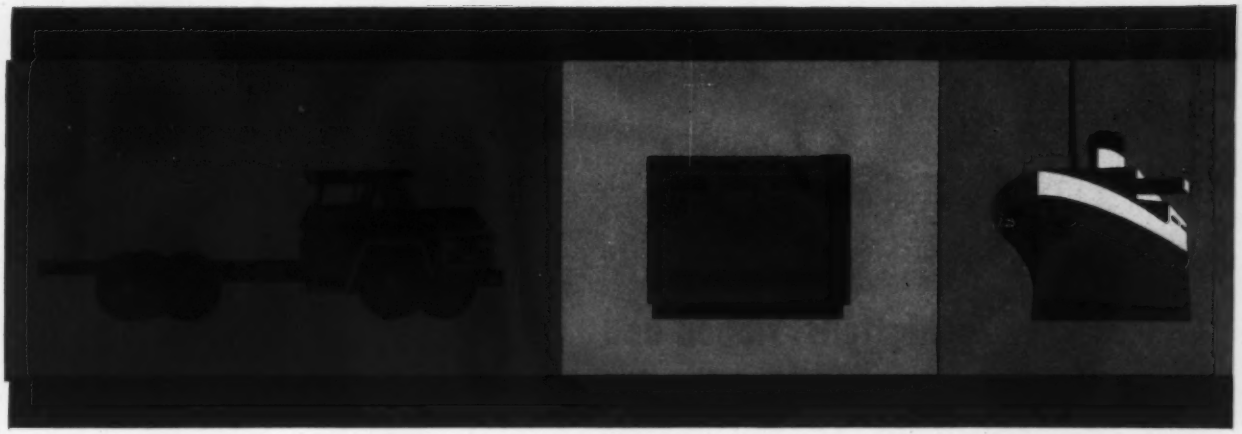


STEEL



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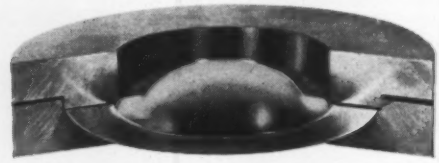

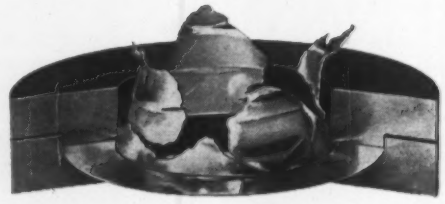

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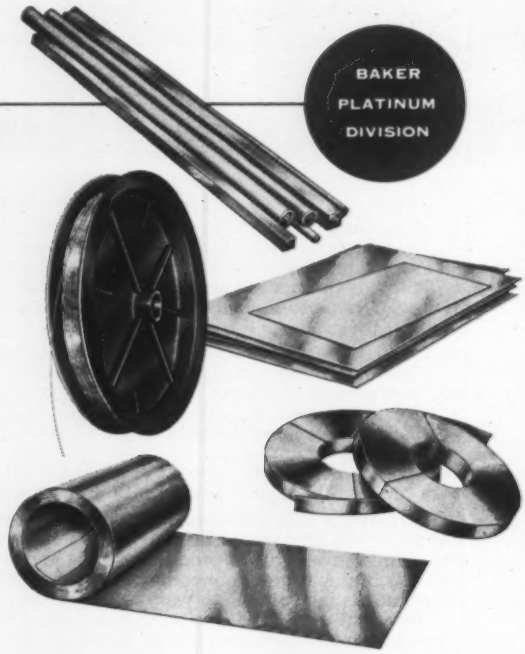

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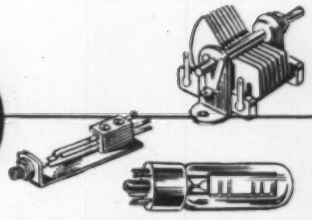

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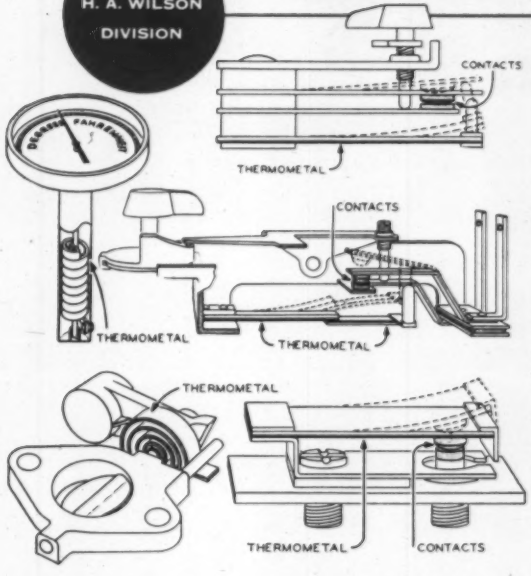

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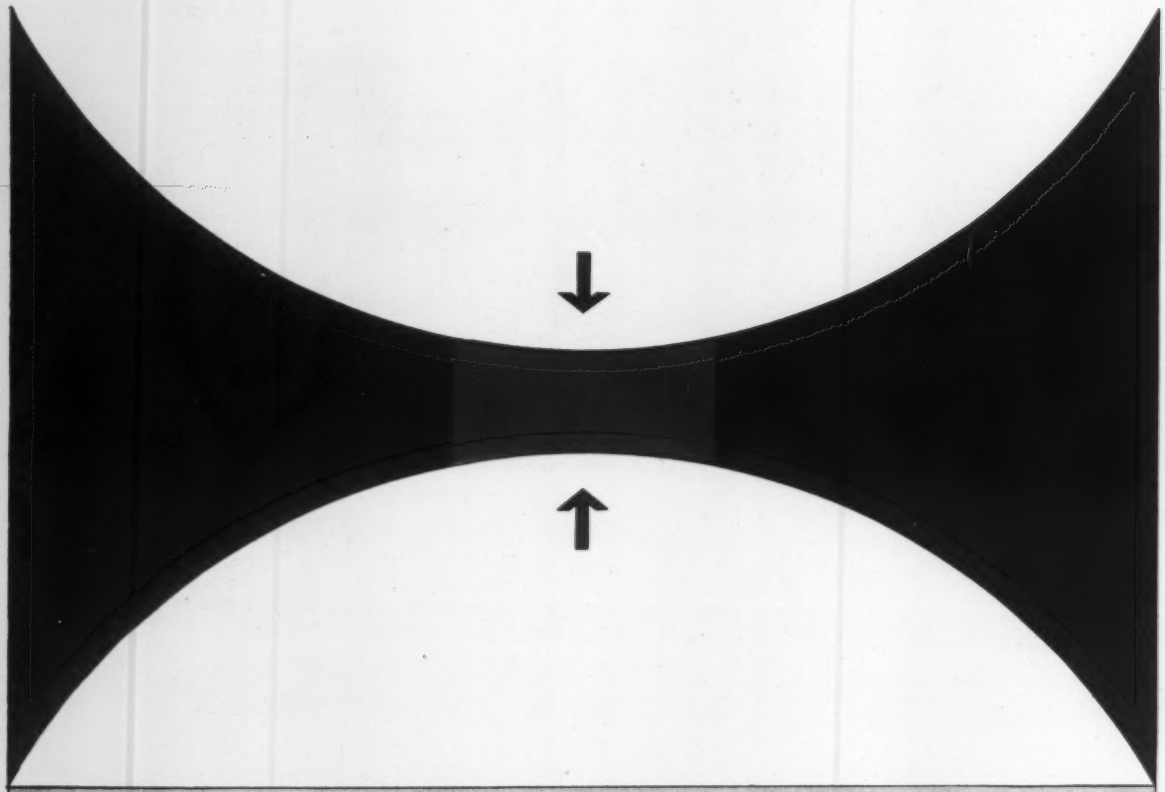

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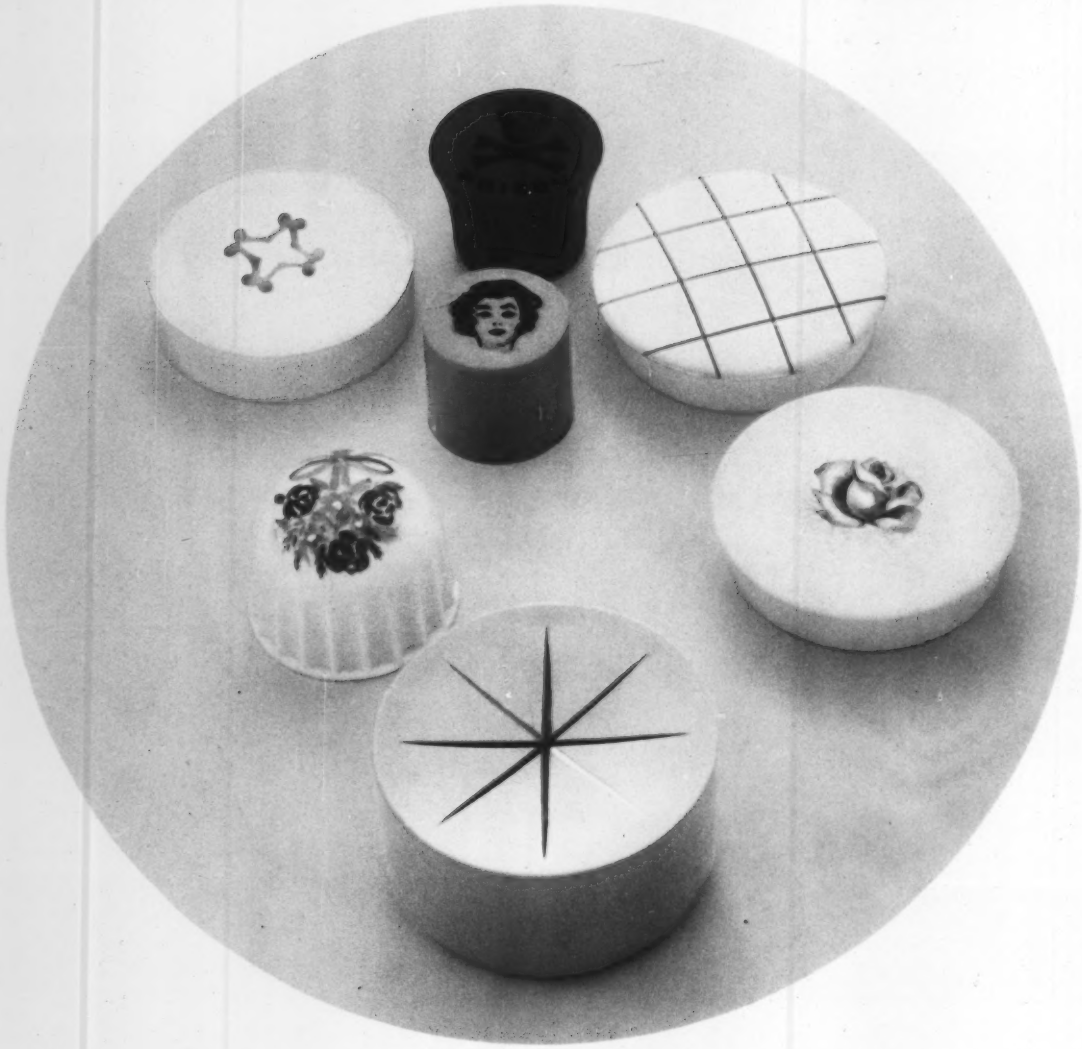
Plaskon NYLON FILMS ARE TOUGH RESIST OIL AND GREASE

Plaskon Nylon Films protect a wide variety of hard-to-hold packaged goods with a combination of top-grade properties . . . **High strength:** Over 10,000 psi tensile; 2 to 4 times stronger than conventional films. **Abrasion resistance:** Tabor tests show 4 to 6 times more wear resistance. **Transparency:** Excellent — variable as desired. **Oil and chemical resistance:** Outstanding...outperforms all other films. **Odor barrier properties:** Outstanding. Tests show superiority over other commercial films. **Printing and dyeing properties:** Good, without special treating . . . flexo and roto. **Heat sealing:** Seals well at 420 to 500°F, 0.5 seconds dwell; impulse seals, too. More complete Nylon Film information is yours for the asking.

PLASTICS AND COAL CHEMICALS DIVISION
40 Rector Street, New York 6, N. Y.

Allied Chemical

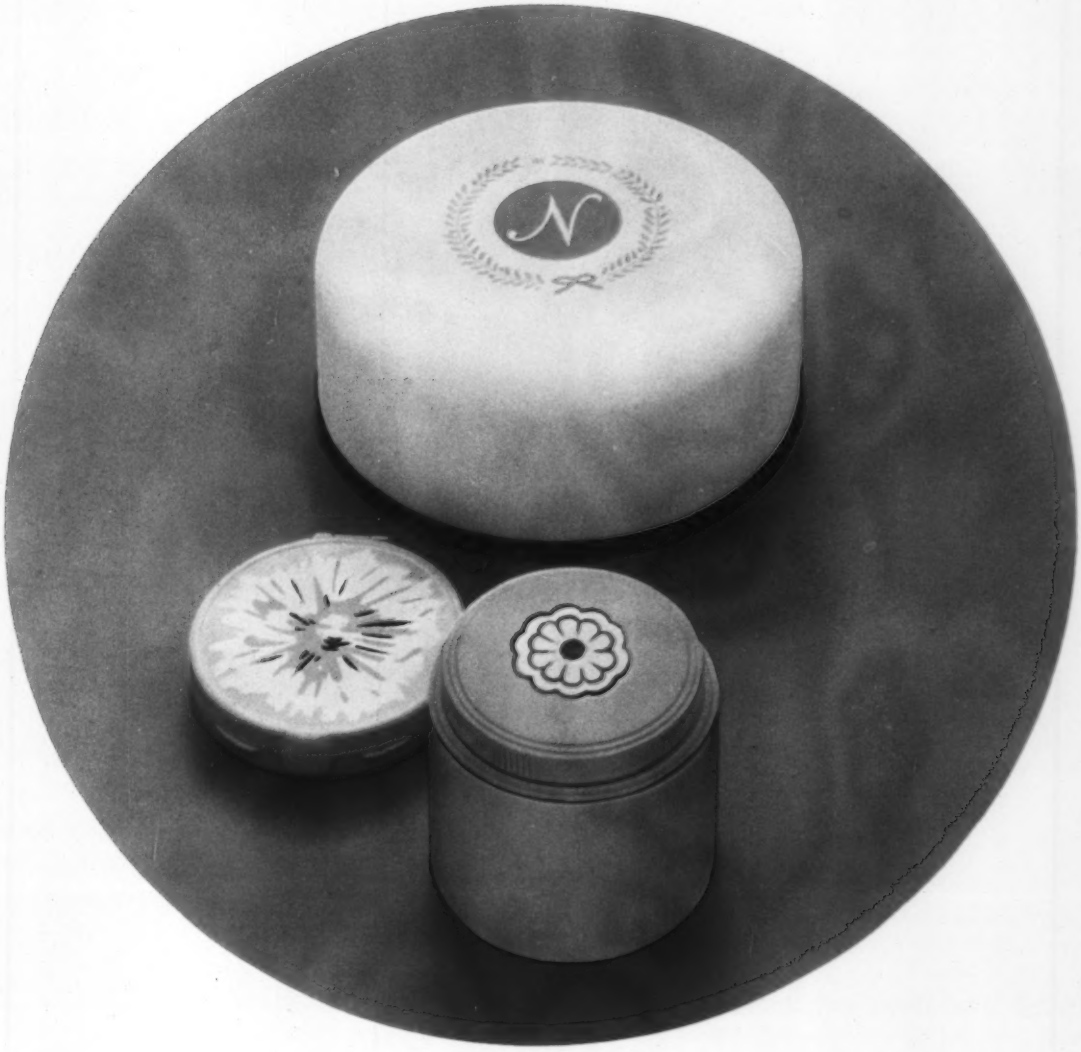
Profitable idea from Plaskon ... FOILS PUT ON UREA CLOSURES



The use of foils can provide a fresh new way to decorate your urea closures and containers. Your old molds are candidates in many instances for a whole new line of gaily decorated closures and containers — at savings not to be overlooked!

Now that it is possible to combine the high quality of urea closures with permanently molded-in decorations, the design possibilities are intriguing — cosmetic caps that add another touch of glamour; pancake makeup boxes with bright, wear-resisting

COLORFUL, LASTING PATTERNS AND CONTAINERS



patterns; dusting powder boxes with sparkling floral designs! In other areas — pharmaceutical closures with molded-in product identification and trademark; brand-name-identified jiggers and secondary closures for liquors.

Foils can now be obtained to brighten alpha cellulose urea and melamine parts . . . including curved surfaces. We'll be happy to work with you to adapt the use of foils to your application.

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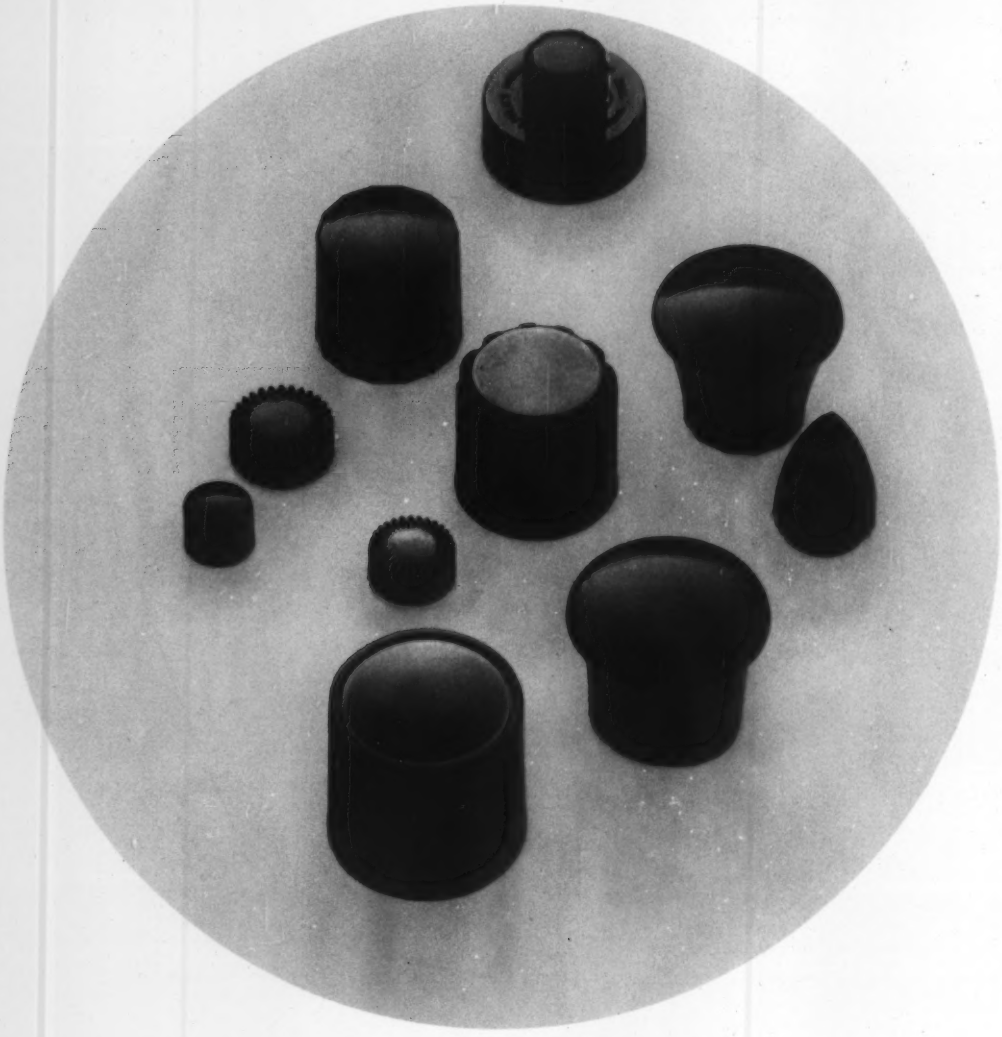
Plaskon WOOD-FLOUR UREA CAPS IT WELL...FOR LESS



Plaskon Wood-Flour Filled Urea beats the closure properties of the older general-purpose plastics — but matches them in cost!

See if your present closure material matches these advantages: Bleed proof and color-fast • Scratch-resistant, non-electrostatic surfaces • Unaffected by ordinary solvents, impermeable to volatiles • High torque strength • Odor-free • Excellent for high-speed automatic production.

Plaskon Wood-Flour Filled Urea, available in closure brown and standard black, is thoroughly checked out and proven in lab and field. It's ready to top your closure savings—and profits. Contact us for more information, and for molded samples.

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Allied Chemical

CORROSION PROBLEMS:

can moly metal's resistance to mineral acids solve them for you?

The following tables show molybdenum's resistance to corrosion by mineral acids, providing oxidizing agents are not present. They also indicate molybdenum's superiority to conventional materials used in handling these acids.

hydrochloric acid

% HCl	temperature, F	aerated	corrosion rate, mils/year* unalloyed molybdenum	14% Si – 3% Mo iron	70% Ni – 30% Mo alloy
5	room	yes (air)	0.40	–	7.8
		yes (oxygen)	0.27	–	–
	160	no	1.1	18.	13.
		yes (oxygen)	1.4	17. (air)	25. (air)
	boiling	no	3.6	79.	13.
20	room	yes (air)	0.10	–	3.1
	160	no	0.58	35.	9.2
		yes (oxygen)	1.4	53. (air)	24. (air)
	boiling	no	0.90	230.	27.
37	room	yes (air)	0.16	–	1.6

*average of five 48-hr periods

hydrofluoric acid

% HF	temperature, F	aerated	corrosion rate, mils/year* unalloyed molybdenum	70% Cu – 30% Ni alloy
25	room	no	0.13	2.6
		yes (air)	0.22	–
	212	no	3.1	55.
		yes (air)	20.	–
49	room	no	0.14	4.1
		yes (air)	0.08	–
	212	no	2.3	75.
		yes (air)	16.	–

*average of five 48-hr periods

phosphoric acid

$\%H_3PO_4$	temperature, F	aerated	corrosion rate, mils/year* unalloyed molybdenum	type 316 stainless steel	70% Ni – 30% Mo alloy
10	room	yes (air)	0.27	nil to 0.18** (oxygen)	1.7
	212	no	2.4	nil to 0.18**	24.
	boiling	no	1.3	nil to 6.7**	19.
50	room	yes (air)	0.25	nil to 0.06** (oxygen)	0.40
	212	no	1.5	1.7	2.5
	boiling	no	1.5	5.4	7.1
85	room	yes (air)	0.20	nil to 0.80** (oxygen)	0.16
	212	no	0.29	20.	0.83
	boiling	no	1.4	770.***	1.9

*average of five 48-hr periods
**range of five 48-hr periods
***one 48-hr period only

sulfuric acid

$\%H_2SO_4$	temperature, F	aerated	corrosion rate, mils/year* unalloyed molybdenum	14% Si iron	14% Si – 3% Mo iron
10	160	yes (nitrogen)	0.22	–	–
		yes (air)	1.4	–	–
		yes (oxygen)	nil to 9.1**	–	–
	boiling	no	6.6	–	–
	400	no	0.77	–	–
20	160	yes (nitrogen)	0.18	–	–
		yes (air)	0.82	–	–
		yes (oxygen)	nil to 3.4**	–	–
	400	no	3.7	–	–
40	160	no	0.74	11.	2.9
		yes (air)	nil to 0.90**	10.0	–
		yes (oxygen)	nil to 1.4**	–	–
	boiling	no	1.5	14.	6.7
50	160	no	0.52	3.4	0.36
		yes (air)	nil to 0.52**	2.3	–
	boiling	no	2.5	5.9	1.6
75	160	no	0.70	0.13	0.20
		yes (air)	nil to 0.15**	nil	–
	boiling	no	34.	0.26	0.68
95	160	no	0.12	0.02	0.28
		yes (air)	nil to 0.21**	0.36	–
	boiling	no	dissolved	–	–

*average of five 48-hr periods
**range of five 48-hr periods

Molybdenum also offers good long-term resistance to attack by liquid metals up to the temperatures given: bismuth (2600 F), gallium (570 F), lead (2190 F), lithium (1650 F), magnesium (1290 F), mercury (1110 F), potassium (1650 F), sodium (liquid and vapor) (1650 F), sulfur (825 F) – and a number of alloys of these and other metals.

FORGING BILLETS OF CLIMELT MOLYBDENUM METALS AND CLIMELT MOLYBDENUM-BASE ALLOYS ARE NOW PROMPTLY AVAILABLE IN STANDARD STOCK SIZES OF 4⅛", 5½", 6", 6½" AND 7" DIAMETERS. BAR STOCK IS MAINTAINED IN A RANGE OF SIZES UP TO 4" DIAMETER.

For complete data, send for these free manuals: "Corrosion Resistance of Molybdenum and Molybdenum-Base Alloys" (24 pages), "Molybdenum Metals" (110 pages), and "Climelt Molybdenum and Molybdenum-Base Alloys" (24 pages). Write:

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CLIMAX MOLYBDENUM COMPANY

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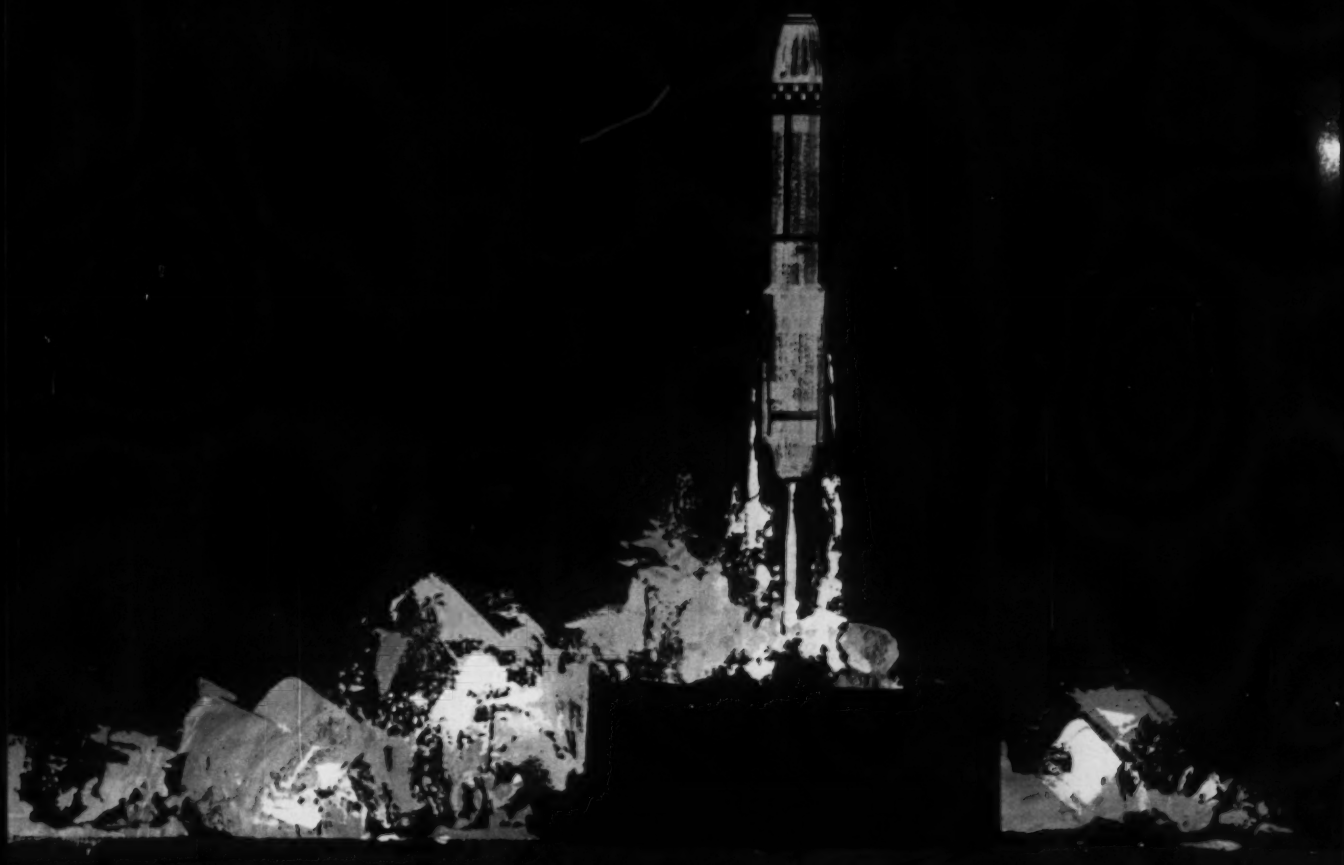
NS SPECIAL WIRE (575,000 psi) WRAPS

In the development of solid-fuel rocket cases, a leading manufacturer fabricated and experimented with welded steel and glass fibers, as well as many steel wire specimens, to find a fuel case material with the most favorable strength-to-weight ratio for fuel case applications.

EARLY DEVELOPMENT STAGES—At the outset of their testing program, the rocket manufacturer asked National-Standard to develop .004″ wire with 575,000 psi, the ultimate tensile strength required of steel wire to provide the strength-to-weight ratio needed. The wire was to be made into tapes of uniformly-stressed wires, coated with epoxy resin to separate the wires, and wound over collapsible mandrels to form the fuel case.

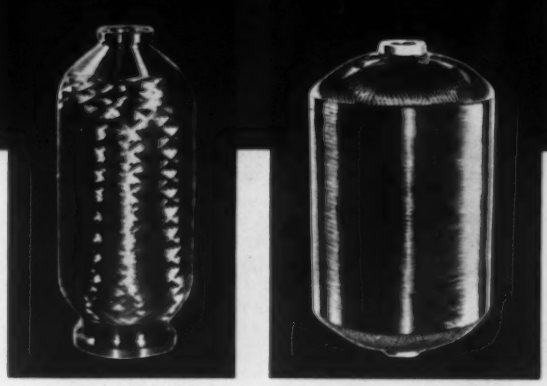
NATIONAL-STANDARD ENGINEERS produced .004″ high-carbon steel wire that met every specification, after intensive testing with many types of wire and finishes. Special wire developed by NS met rigid size tolerances, residual twist and controlled cast requirements.



ROCKET FUEL CASES

The end result of NS—customer cooperation was the ability to produce wire-wrapped rocket cases with very high hoop stress and lower cost than those being produced by other methods. And the fuel case manufacturer is able to provide maximum case-to-case reliability.

EXPERIENCED ENGINEERING HELP of this kind is available to you from National-Standard to meet special or unique high-quality wire applications. Write for additional information to National-Standard Company, Niles, Michigan.



WIRE-WRAPPED ROCKET CASES are wound over collapsible mandrels using a number of strands of very high strength, small diameter wire formed into tapes.

NS NATIONAL-STANDARD COMPANY

Manufacturer of Specialty Wire and Metal Products

NATIONAL-STANDARD COMPANY

Niles, Michigan

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Whatever your platinum needs, it will pay you to investigate Metals & Controls for solid or clad platinum.

In addition, Metals & Controls has complete fabricating facilities to blank, spin, form, draw, turn, and machine platinum parts . . . and to stake, weld or braze assemblies.

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- Alloys platinum-group metals.
- Produces chemical compounds for catalysts and for electro-plating solutions.
- Produces solid and clad metals as sheet — foil — wire — tubing — gauze.
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Suppliers' New Bulletins

High Alloy Castings. Alloy Casting Inst., 4 pp. Revised list of standard designations and chemical composition ranges for heat and corrosion resistant cast alloys. Included in the list of 32 grades are two new corrosion resistant alloys. 1

Coatings for Vacuum Metallizing. Bee Chemical Co., Logo Div., 45 pp. Uses, methods of application, and other data on base coats and top coats for vacuum metallizing thermoplastics, thermosetting plastics, metals and glass. Also discussed are spraying, dipping and flow coating. 2

Polymer Catalogue. Borden Chemical Co., Div. of Borden Co., 12 pp. Properties, uses, viscosity, particle size, specific gravity and other technical data on a line of polymer products. 3

ABS Plastics Price List. Borg-Warner Corp., Marbon Chemical Div., 6 pp. Ordering information, available grades, standard colors and prices of ABS plastics molding pellets and powdered resins. 4

Corrosion of Wrought Iron. A. M. Byers Co., 12 pp. Results of eight-year corrosion tests on wrought iron and 10 structural steels in salt water and lake water environments. Included are comparative corrosion-time curves, weight loss tables and complete details on test materials, conditions, methods and results. 5

Nonferrous Tubing. Calumet & Hecla, Inc., Wolverine Tube Div., 12 pp. Compositions, specifications, sizes, and lengths of various copper and aluminum alloy standard and condenser and heat exchanger tubing. 6

High Temperature Materials. Carborundum Co., Advanced Materials Technology, 8 pp, illus. Properties, uses and general information on 26 materials designed to resist abrasion, corrosion, nuclear radiation and high temperatures. Included are various metals and alloys and several carbides, nitrides and oxides. 7

High Temperature Ceramic Fiber. Carborundum Co., Research & Development Div., Ceramic Fiber Project, 8 pp, illus. Properties, available forms and current uses of a ceramic fiber designed to withstand operating temperatures up to 2300 F. 8

Cobalt Compounds. Cobalt Information Center, c/o Battelle Memorial Inst., 505 King Ave, Columbus 1, Ohio, 2 pp. Properties and uses of 46 organic and inorganic cobalt compounds, including formula, molecular weight, specific gravity, melting point and solubility. Write on company letterhead directly to Cobalt Information Center.

Steel Bar and Tubing Digest. Columbia Steel & Shafting Co., Summerill Tubing Co. Div., 8 pp, illus., Vol. 1, No. 1. Periodic publication consists of general information on ordinary and unusual applications of bars and tubing. This and future issues will include material designed to aid in the proper application and specification of steel bars and tubing. 9

Plastics Catalogue. Commercial Plastics & Supply Corp., 64 pp. Information on prices and how to order plastics sheet, rod, tube and film. Practically all plastics are covered including new grades and laminates. 10

Steel Tubing Catalogue. Copperweld Steel Co., Ohio Seamless Tube Div., 8 pp, illus., No. CS-60. General information, specifications, tolerances, fabrication data and uses of carbon and alloy steel seamless tubing and carbon steel electric welded steel tubing. 11

TFE, Nylon Shapes. John L. Doré Co., 8 pp, illus., No. A-59. Properties, uses and design data for TFE and nylon couplings, expansion joints, tape, o-rings, packings, and molded shapes. 12

Magnesium, Aluminum. Dow Metal Products Co., Div of Dow Chemical Co., 12 pp, illus. Information on facilities for producing magnesium and aluminum sand, permanent mold, and die castings; rolled and extruded products; and fabricated products. 13

Trichlorethylene Painting Process. E. I. du Pont de Nemours & Co., Inc., Electrochemicals Dept., Chlorine Products Div., 16 pp, illus. General description, advantages, uses and costs of a trichlorethylene painting process. 14

TFE Fluorocarbon Plastics. E. I. du Pont de Nemours & Co., Inc., Polychemicals Dept., 20 pp, illus, No. A-13783. Mechanical properties, chemical resistance, electrical characteristics and thermal properties of TFE fluorocarbon plastics in terms of specific applications. Case histories describe the advantages of TFE for such things as seals, piston rings, valves, antistick materials, and electrical insulation. 15

Felt Design Book. Felters Co., 24 pp. Information on design properties of felt, descriptions of special treatments, and data on how to select the proper shapes and dimensions for specific applications. Also included are data on felt lubrication seals, gaskets, wicking and filters. 16

Stainless Steel Specifications. Peter A. Frasse & Co., Inc., Sec. A, No. 1. Chart provides chemical compositions and nearest SAE and AMS designations for 40 standard AISI grades of stainless steel and 18 special grades, including precipitation hardening stainless steels. 17

Alumina and Steatite Ceramics. Globe-Union, Inc., Centralab Electronics Div., 4 pp, illus., No. 42-874. Reference folder contains 3 useful tables: temperature conversion from Centigrade to Fahrenheit, decimal equivalents of fractions, and mechanical and electrical properties of high alumina and steatite ceramics. Also included is a list of design considerations for ceramic products. 18

Rigid Polyvinyl Sheet. B. F. Goodrich Chemical Co., Div. of B. F. Goodrich Co., 20 pp, illus., No. G-17. Physical properties, corrosion resistance, effect of temperature on tensile strength, creep data and other technical information on rigid polyvinyl sheet. 19

Engineered Iron Castings. Hamilton Foundry, Inc., 12 pp, illus. General information on engineering facilities and services offered for the production of iron alloy castings. Included is a comparative properties chart and a description of standard high nickel and ductile iron castings. 20

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Hollow Aluminum Bar. Harvey Aluminum, 8 pp, illus. Standard sizes, wall thicknesses, dimensions, tolerances, mechanical properties and specifications for hollow aluminum bar stock. **21**

Nickel Alloy Steels. International Nickel Co., Inc., 27 pp. Buyers Guide lists available grades and companies supplying nickel alloy steels. **22**

Flame Spray Process. Metallizing Engineering Co., Inc., 16 pp, illus., No. 136B. General information on flame spraying processes, their advantages and uses. Also included is specific information on hardness, tensile strength, bond strength, etc. of various coatings used. **23**

Mechanical Finishing Material. Minnesota Mining & Mfg. Co., Abrasives Div., 4 pp, illus. General information and typical uses of a non-woven nylon web material used to mechanically finish metal surfaces. **24**

Elastomer Compounds. Minnesota Mining & Mfg. Co., Chemical Div., 2 pp, illus. Properties, specifications and uses of a new elastomer compound designed for long time service at 400 F. **25**

Electrical Tapes. Minnesota Mining & Mfg. Co., Electrical Products Div., Scotchbrand, 32 pp, illus. Properties, characteristics, advantages, uses and specifications for a line of pressure sensitive adhesive electrical tapes. **26**

Polycarbonate Plastics. Mobay Chemical Co., Merlon Div., No. TIB-41-M1. Physical and electrical properties, and typical uses of polycarbonate plastics. **27**

Coatings and Processes. Neilson Chemical Co., 6 pp, illus., No. 59-170. General information on iron and zinc phosphate coating chemicals and processes for steel and aluminum surfaces; conversion and oxide coatings for aluminum surfaces; rust removers; metal conditioners; metal etchants; alkaline and acidic metal cleaners; spray booth compounds; steam cleaners; and hot or cold paint strippers. **28**

Metal Powder Part Design. New Jersey Zinc Co., 24 pp, illus. General information on the powder metal process and its current uses. Covered are compositions and properties of nonferrous alloys, commercial tolerances, practical design suggestions and elements affecting cost. Included are 27 case histories showing uses of brass and nickel silver metal powder parts. **29**

Aluminum Alloy Selector. Olin Mathieson Chemical Corp., Metals Div., 24 pp, illus., No. OA-11. Physical properties, fabrication characteristics and economic advantages of a wide variety of aluminum sheet, plate, rod, bar, extrusion and casting alloys. **30**

Industrial Plastics. Polymer Corp. of Pennsylvania, 12 pp, illus., No. BR-1. Mechanical, thermal, electrical and chemical properties; machinability; typical applications; stock sizes; and other information on nylon, TFE, polycarbonate, chlorinated polyether, and other plastics materials. **31**

Cellulose. Rayonier Inc., 12 pp. Comprehensive article covers production, consumption, prices, supply, typical uses and other information on chemical cellulose. **32**

Nonferrous Centrifugal Castings. Shenango Furnace Co., Centrifugally Cast Products Div., 4 pp, illus., No. 157. Comparative specifications, chemical analyses and minimum physical properties of nonferrous centrifugal casting alloys. Included are tin bronzes, aluminum bronzes, manganese bronzes, brass, silicon bronzes, nickel alloys and special alloys. **33**

Filament Wound Glass-Epoxy. A. O. Smith Corp., 2 pp, illus., No. MP-61. Properties, advantages and uses of filament wound glass-epoxy products for electrical applications. **34**

Dip Coating Process. Steere Enterprises, Inc., 4 pp, illus. Advantages, uses and characteristics of a low cost dipping process which produces plastics products, plastic-coated metal parts and protective covers for precision machined parts. **35**

Copper-Clad Laminate. Taylor Fibre Co., 2 pp, No. 3.1.8.2. General description and characteristics, tolerances, available forms, electrical properties, and uses of a new punching grade copper-clad electrical laminate. **36**

Industrial Finishes. United Lacquer Mfg. Corp., 2 pp. Color card shows 64 shades available in lacquers, synthetics, vinyls and specialty finishes in a complete scale of lusters. Finishes include wrinkles, metallics, pearlized, crystal, etc. **37**

High Alloy Castings. U. S. Magnet & Alloy Corp., Steel Alloy Castings Div., 4 pp, illus. Advantages of an alloy casting process which is said to eliminate many expensive and time-consuming finishing operations. **186**

Galvanized Steel Sheet. U. S. Steel Corp., 32 pp, illus. General information, typical uses and cleaning and fabrication data for galvanized steel sheet. **38**

Molybdenum. Universal-Cyclops Steel Corp., 22 pp. Chemical composition, structure, mechanical properties, dimensions, finish, inspection and other information on unalloyed molybdenum and molybdenum alloy billets, bars, plates and sheets. **39**

Stainless Steels. Vanadium Corp. of America. Information on the history of stainless steel from original experiments through the first large scale production in the United States to the development of present day stainless steels. **40**

Thermosetting Plastics Laminates. Westinghouse Electric Corp., Micarta Div., 8 pp, Nos. 63-060 and 63-061. Specifications, weight, hardness, bonding and dielectric strength, dissipation, resistivity, tolerances and other information on 23 paper and fabric-base thermosetting plastics laminates for switchboard panels, marine bearings and electronic components. **41**

Other Available Bulletins

Irons & Steels • Parts • Forms

Alloy Gray Iron Castings. Advance Foundry Co., 2 pp, illus., No. 4. Design information and uses of high alloy, high strength gray iron castings. **42**

Ductile Iron Parts. American Cast Iron Pipe Co., Special Products Div., 36 pp, illus. Grades, dimensions, weights, uses and specifications for ductile iron piping, rolls and other parts. **43**

Drop Forgings. Bethlehem Steel Co., 6 pp, illus., No. 662. Shows how Bethlehem Steel Co. drop forges jet aircraft parts. Information on other drop forgings produced by the company. **44**

Steel Forgings. Cameron Iron Works, Inc., Special Products Div., 44 pp, illus. Dimensions and weights of various shapes and forms forged of stainless and alloy steel. Shows how forgings are made. **45**

Steel Wire. Continental Steel Corp., 12 pp, illus. Information on standard and special-shaped wire, coarse round wire, and fine and specialty wire made of low and medium-low carbon steel. **46**

Electric Furnace Steels. Copperweld Steel Co., Aristoloy Steel Div., 48 pp, illus. Facilities of company for melting, rolling, finishing, heat treating and conditioning electric furnace steels. Rolling limits and chemical analysis are also given. **47**

Metal Powder Parts. Dixon Sintaloy, Inc., 12 pp, illus. Typical characteristics of some ferrous and nonferrous metal powders, general description of sintering process, design data and advantages and typical uses of various metal powder parts. **48**

Metallic, Nonmetallic Forms. Dumont Corp., 28 pp, illus. Information on honeycomb sandwich structures, metal-to-metal bonded parts, high temperature molded plastics, special purpose fiberglass laminates and hand lay-up custom moldings. **49**

Permanent Mold Castings. Eaton Mfg. Co., Foundry Div., 18 pp, illus. Describes Eaton permanent mold process for producing gray iron castings. **50**

Steel Analysis. Jones & Laughlin Steel Corp., Stainless & Strip Div., 20 pp. Compositions and SAE, AISI and AMS numbers for 40 stainless steels, 184 alloy steels and 105 carbon steels. **51**

Steel Bars. La Salle Steel Co., 5 pp. Wall chart listing machinability ratings and weight of all AISI grades of cold-finished steel bars. **52**

Air Hardening Steel. Latrobe Steel Co., 8 pp, illus. Physical and mechanical properties, heat treatment, composition and high temperature properties of an air hardening steel. **53**

Clad Steels. Lukens Steel Co., 32 pp, illus. Mechanical and chemical properties, sizes, uses, design information and fabrication data for a series of nickel, stainless steel, Inconel and monel-clad steels. **54**

Malleable Iron Castings. Malleable Founders Society, 8 pp, illus. Design considerations, machinability, and impact and corrosion resistance of standard and pearlitic malleable iron castings. **55**

Spring Steels. National-Standard Co., Athenia Steel Div., 28 pp, illus., No. 579. Facilities for producing cold-rolled high carbon flat spring steels. **56**

Wire Cloth. Newark Wire Cloth Co., 4 pp, illus. How to select, use and check various grades and types of wire cloth. **57**

Steel Tubing Weight Tables. Revere Copper & Brass Inc., 14 pp. Dimensions and weights for hot finished and cold drawn round steel tubing. **58**

Bolts, Forgings. Rhode Island Tool Co., 26 pp, illus., No. 75. Dimensions, properties, prices and uses for drop and upset forgings, eye and special bolts, studs, cap screws, and nuts. **59**

Metal Stampings. Rockwell-Standard Corp., Stamping Div., 8 pp, illus. Describes facilities for producing stampings and assemblies in any metal or alloy. **60**

Vinyl-Metal Laminates. Clad Rex Div., Simoniz Co., 8 pp, illus. Gives physical, chemical and thermal properties, and abrasion resistance of vinyl-metal laminates. **61**

Steel Tubing. Standard Tube Co. Physical properties and weight of steel tubing for shafting, structural members and mechanical parts. **62**

Welded Honeycomb Cores. Swedlow Inc., 10 pp, illus., No. N. Heat resistance, strength-weight ratios and compression strength of welded honeycomb cores made of stainless steel, titanium and Inconel X. **63**

Small Metal Parts. Torrington Co., Specialties Div., 24 pp, illus. Services and facilities of the company for producing small precision metal parts. Information also on contract swaging and swaging machines. **64**

Columbium in Steel. Union Carbide Metals Co., Div. of Union Carbide Corp., 4 pp. Discusses the use of ferrocolumbium in carbon and low alloy steels, high temperature alloys, stainless steel and plain chromium steels. **65**

Cold Formed Parts. Van Huffel Tube Corp., 48 pp, illus. Information on cold formed metal parts. **66**

Magnetic Perforating Dies. S. B. Whistler & Sons, Inc., 21 pp, illus., No. M-45. Catalog of magnetic perforating dies for perforating materials up to and including ¼-in. thick mild steel. **67**

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Electrolytic Copper Powder. American Metal Climax, Inc., 8 pp, No. CP-101. Describes the operation, equipment and quality control used in the production of electrolytic copper powder. **69**

Bearing Bronze. American Smelting & Refining Co., Continuous Cast Dept., 6 pp, illus., No. 301. Gives stock sizes and weights for solid and hollow continuous-cast bronze bars ½ to 9 in. in dia. **70**

High Strength Aluminum Casting Alloy. Federated Metals Div., American Smelting & Refining Co., 6 pp, illus. Physical and mechanical properties, specifications, composition and foundry characteristics of a high strength aluminum casting alloy that requires no heat treatment. **71**

Magnesium Products. Brooks & Perkins, Inc., 8 pp, illus. Shows the fabrication, assembly and finishing of magnesium tail cones for aircraft, teleprinter covers, gun turret enclosures and radar plotting equipment. Information also on other magnesium products. **72**

Beryllium Heat-Sink. Brush Beryllium Co., 20 pp, illus. Design and fabrication data on the beryllium heat-sink used in NASA's Project Mercury. **73**

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Aluminum Castings. Exalco Mfg. Co., 4 pp, illus. Information on standard and custom-made aluminum permanent mold castings. **75**

Tantalum Sheet, Foil. Fansteel Metallurgical Corp., Metals & Fabrication Div., 6 pp, No. 2.602-1. Ordering data, prices, sizes and tolerances for tantalum sheet and foil. **76**

Metallic, Nonmetallic Stampings. Federal Tool & Mfg. Co., 6 pp, illus., No. 301. Design information, tolerances and specifications for stampings made of ferrous and nonferrous metals, and phenolic, nylon and epoxy resins. **77**

Aluminum Alloy. Frontier Bronze Corp., 24 pp, illus. Describes Alloy 40-E, a high strength aluminum alloy that needs no heat treatment. **78**

Nonferrous Metal Powders. Glidden Co., Chemical Divs., Metals Dept., 6 pp. Information on lead and Kesistox copper powders. **79**

Precision-Made Parts. Hamilton Watch Co., Precision Metals Div., 16 pp, illus. Special alloy casting, rolling, drawing to fine specifications. **80**

Indium Alloys. Indium Corp. of America, 93 pp, graphs. Constitution of indium alloy systems. **81**

Beryllium Copper Parts. Instrument Specialties Co., Inc., 20 pp, illus., No. 10. Design information, properties and uses of beryllium copper springs and screw machine products. **82**

Copper Powder. Malone Metal Powders, Inc., 4 pp, illus. Describes Fernlock Copper, made by electrolysis and having a dendritic particle shape and low density. **84**

Nonferrous, Ferrous Expanded Metal. North American Cement Corp., Designers Metal Corp., 4 pp, illus., No. 4591. Styles, weights and sizes of aluminum and carbon steel expanded metal. **85**

Nonferrous Castings. Ohio Precision Castings, Inc., 16 pp, illus. Information on castings made from brass, bronze, aluminum and beryllium copper. **86**

Specialty Tubing. Olin Mathieson Chemical Corp., Western Brass Mills Div., 8 pp, illus. Processing information, technical data and typical applications of special tubing designed into a single, homogeneous sheet of metal. **87**

Nickel-Clad Copper Wire. Riverside-Alloy Metal Div., H. K. Porter Co., Inc., No. T-3. Properties, advantages and applications of nickel-clad copper wire. **88**

Deep Drawn Shapes. Pressed Steel Tank Co., 2 pp, illus. Information on cylindrical, spherical, conical and tapered deep drawn shapes and shells made of ferrous and nonferrous metals. **89**

Zinc Die Castings. St. Joseph Lead Co., 22 pp, illus. Discusses zinc die casting alloys and commercial finishes for zinc die castings. **90**

Tin-Plated Nonferrous Strips. Somers Brass Co., 1 pp, illus. Data and specification sheet covering tin plating of a wide range of nonferrous thin metal strips. **91**

Spun Metal Parts. Spincraft, Inc. Metal spinning and fabrication of spun metal parts. **92**

Steel-Clad Copper Wire. Sylvania Electric Products Inc., Parts Div., 4 pp. Conductivity, composition, availability, standard tolerances, uses and mechanical properties of a stainless steel-clad copper wire. **93**

Ferrous, Nonferrous Wire, Strip. E. H. Titchener & Co., Custom Design Dept., 22 pp, illus. Finishes, sizes, types and typical applications of fer-

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rous and nonferrous wire and strip. **94**

Corrosion Resistant Alloy. Haynes Stellite Co., Div. of Union Carbide Corp., 16 pp, illus. Corrosion resistance, chemical composition, physical properties, hardness, formability, impact strength and short-time tensile strength for a nickel-base alloy called Hastelloy alloy C. **95**

Phosphor Bronze Sheet. Waterbury Rolling Mills, Inc., 4 pp, illus. Information on formability, fatigue life, surface finish and grain structure of annealed and tempered phosphor bronze sheet and strip. **96**

Cadmium, Lead and Tin Products. White Metal Rolling & Stamping Corp., 4 pp. Properties and uses of cadmium, lead and tin sheets, plates, strips, wires and rods. **97**

Closed-Die Forgings. Wyman-Gordon Co., 12 pp, illus. Facilities for producing closed-die forgings of aluminum, magnesium, steel and titanium. **98**

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Polyester Resins. Celanese Corp. of America, Plastics Div., 8 pp, No. M2J. Formulation and molding of thixotropic liquid, unsaturated polyester resins. **105**

Molded Plastics. Chicago Molded Products Corp., 8 pp, illus. Several case histories describe design and selection of molded plastics parts. **83**

TFE Gaskets. Chicago Rawhide Mfg. Co., Sirvene Div., 4 pp, illus., No. CT-1. Properties of Sirvene TFE packings, bearings, gaskets and rings. **106**

Epoxy Resins. Ciba Co., Inc., Plastics Div., 10 pp, illus., No. 25. Typical properties, applications, pot life and curing cycles for an epoxy resin. **107**

Epoxy Compounds. Clinton Co., 4 pp. Properties and uses for a series of special epoxy formulations. Information also on color pastes for epoxies. **108**

Silicone Rubber. Colonial Rubber Co., 3 pp. Physical properties, sizes and uses of 50, 70 and 80 Durometer silicone rubber sheets. **109**

Silicone Products. Dow Corning Corp., 16 pp, illus., No. 1-114. Properties and uses of silicone rubber, adhesives, additives, electrical insulation, lubricants, protective coatings and textile finishes. **110**

Cellophane Film. E. I. du Pont de Nemours & Co., Inc., Film Dept., 10 pp, illus. Properties and uses of over 100 varieties of cellophane film. **111**

Butyl Rubber. Enjay Co. Inc., 12 pp, illus., No. 2d/En. Weather, sunlight, chemical, solvent and heat resistance, electrical properties and uses of butyl rubber. **112**

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Flame Retardent Polyethylene. W. R. Grace & Co., Polymer Chemicals Div., 6 pp. Physical and electrical properties, and uses of flame retardent polyethylene resins. **117**

Injection Molded Acetal. Gries Reproducer Corp., 8 pp, illus., No. 1001. Mechanical, chemical and physical properties of acetal plastics, including a table of approximate dimensions and weights in which molded parts can be specified. **118**

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Epoxy Resins. Reichhold Chemicals, Inc., 16 pp, Nos. ER-1, 2, 3, 4, 5 and 6. Hand lay-up, casting and potting procedures, properties, uses and storage life of epoxy resins and hardeners. **121**

Polyethylene Resins. Spencer Chemical Co., 32 pp, illus. Properties and uses of low and medium density polyethylene resins. **124**

Small Plastics Parts. Standard Plastics Co., Inc., 8 pp, illus. Describes a custom service for molding thermoplastic and thermosetting resins into small plastics parts, such as lenses, bearings and jewelry. **125**

SBR Rubber. Texas-U. S. Chemical Co., 23 pp. Information on light colored, oil extended and black masterbatch SBR rubbers. **127**

Synthetic Rubber. Naugatuck Chemical Co., Div. of United States Rubber Co., 12 pp, No. 219. Compounding information, physical properties, oil and ozone resistance, and uses of a vinyl modified synthetic rubber called Paracril OZO. **129**

Nitrile Thermoplastic Sheet. Royalite Plastic Products Div., U. S. Rubber Co., 4 pp, illus. Advantages of using a nitrile thermoplastic sheet material called Royalite in luggage. **130**

Rubber Parts. Williams-Bowman Rubber Co., 1 p. Dimensional tolerances for extruded and molded rubber gaskets, washers and rubber-covered rolls. **131**

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Cemented Carbide Parts. Allegheny Ludlum Steel Corp., Carmet Div., 32 pp, illus., No. C-16. Dimensional data, design information, prices and uses of cemented carbide parts. **132**

Properties of Ceramics. American Lava Corp., Steatite Div., 8 pp, No. 591. Physical, mechanical and electrical properties of steatite, forsterite, cordierite, lava, alumina and magnesium silicate ceramics. Also gives properties of silicon carbide and zirconium oxide. **133**

Alumina Ceramics. Coors Porcelain Co., 4 pp, illus., No. 858. Mechanical and electrical properties, dimensional data and design information for high strength alumina ceramics for use in rockets and missiles. **135**

Graphite. Graphite Specialties Corp., 4 pp, No. GS-101-1. Chemical and physical properties of an impervious graphite for high temperature parts. **136**

Thermal Insulation. Johns-Manville Sales Corp., 54 pp, illus., No. IN-244-A. General description, typical applications, available forms and types, advantages, and specifications of a line of thermal insulation materials. **137**

Specialty Papers. Knowlton Bros., Inc., 12 pp, illus. Information on technical and industrial specialty papers. Shows company research and manufacturing facilities. **138**

Red Lead Primer. Lead Industries Assn., 4 pp, No. 14. Properties of a new red lead primer for seawater immersion. **139**

Industrial Ceramics. McDanel Refractory Porcelain Co., 4 pp, illus. Briefly describes ceramic pump pistons, combustion tubes, heat reflectors, crucibles and liners. **140**

Metal-Faced Plywood. Met-L-Wood Corp., 4 pp, illus. Shows typical installation of Met-L-Wood riser enclosures for air conditioning pipe enclosures and ducts. **141**

Carbon Parts. Morganite Inc., 12 pp, illus. Chemical and physical properties and sizes of carbon parts. **142**

Paper Products. Mosinee Paper Mills Co., 3 pp, illus. Outlines uses and advantages of a flame resistant paper and average physical properties of flat and creped neutral papers. **143**

Ceramic Insulators. Norton Co., 4 pp, illus., No. CP12.1. Uses and specifications of fused magnesium oxide, aluminum oxide and zirconia insulators for thermocouple tubing. **145**

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Carbon, Graphite. Speer Carbon Co., 8 pp, No. 7/57-AD. Information on carbon and graphite for high temperature applications. Information also on sizes of carbon and graphite products. **147**

Carbon, Graphite Products. National Carbon Co., Div. of Union Carbide Corp., 4 pp, illus., No. 5008. Dimensions and characteristics of carbon, graphite and impervious carbon and graphite equipment for chemical processing applications. **149**

Silanes. Union Carbide Corp., Silicones Div., 16 pp, illus., No. SP-1160. Physical and chemical properties, specifications and uses for 24 silanes. **150**

Treated Felts. Western Felt Works, Treated Felts Section. Properties and uses of felts treated with TFE, polyester and polyethylene resins. Contains samples. **152**

Finishes • Cleaning & Finishing

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Metal Finishing. Enthone, Inc., 4 pp. Lists the company's metal finishing processes and electroplating chemicals. Includes a card offering technical data on 77 metal finishing subjects. **156**

Bright Nickel Plating. Harshaw Chemical Co., Scientific Div., 4 pp, illus. Advantages of Nubright bright nickel plating process. **157**

Conversion Coating. Parker Rust Proof Co., 4 pp, illus. Latest applications of chemical conversion coating. **158**

Porcelain Enamel. Porcelain Enamel Institute, 1145 19th St. N. W., Washington 6, D. C. File folder covers general information about porcelain enamel, gives characteristics, properties and corrosion resistance of porcelain enamel. Write on company letterhead directly to Porcelain Enamel Institute.

Spray Painting. Ransburg Electro-Coating Corp., 12 pp, illus. Operating principles, advantages and typical uses of an electrostatic hand gun for spray painting. **159**

Joining & Fastening

High Pressure Seals, Fasteners. A. P. M. Co., 4 pp, illus., No. C. General information, military specifications and typical uses of a line of high pressure seals, boots and mechanical fasteners. **160**

Resin Adhesives. American Cyanamid Co., Plastics & Resins Div., 100 pp. Properties, uses and methods of application in the plywood and woodworking industries of urea-formaldehyde, melamine-urea formaldehyde and straight melamine resin adhesives. **161**

Fluorocarbon Etchant. Chemgineers, Inc., 2 pp, No. 369. Information on a solution used to prepare the surface of fluorocarbon plastics for bonding, including instructions on cleaning, methods of application and safety precautions. **162**

Mechanical Fasteners. Huck Mfg. Co., 24 pp, illus. Driving cycles, strength data, typical applications, grip ranges, significant dimensional data, whole size recommendations and other information on a line of mechanical fasteners. **164**

Adhesives. Interchemical Corp., Finishes Div., 8 pp, illus. No. 7/in. General characteristics, formulations, and typical applications of a line of custom formulated adhesives. **165**

Structural Adhesives. Minnesota Mining & Mfg. Co., Adhesives, Coatings & Sealers Div., 900 Bush Ave., St. Paul 6, Minn., 16 pp, illus. Information on design, bonding and use of a line of structural adhesives. Included are properties, curing data, joint design and case histories illustrating how adhesives solve structural assembly problems. Write direct to Minnesota Mining on company letterhead.

Mechanical Fasteners. National Machine Products Co., 8 pp, illus. Information on sizes, uses and advantages of a line of mechanical fasteners. **167**

Adhesives, Coatings. Raybestos-Manhattan, Inc., Adhesives Dept., 16 pp, illus., No. 700. Properties and uses of adhesives, coatings and sealers manufactured by the company. **168**

Screw Fastening Aluminum. Reynolds Metals Co., 48 pp, illus., No. 802-203. Information on various types of standard and special fasteners and fastening systems used to join aluminum assemblies. **169**

Fasteners. Simmons Fastener Corp., 42 pp, illus., No. 1257. Sizes, installation data, characteristics and uses of plastics and metal fasteners. **170**

Screw Thread Root Design. Standard Pressed Steel Co., 20 pp, illus. Discusses shape at the root of screw threads as a function of tension bolt failures, and describes how to avoid such failures. **171**

Methods for Joining Metals. Linde Co., Div. of Union Carbide Corp., 36 pp, illus. Discusses various welding techniques for joining ferrous and nonferrous metal parts such as tanks, railroad cars, condensers and bulldozers. **172**

Pop Rivets. United Shoe Machinery Corp., "Pop" Rivet Div., 8 pp, illus. General description, advantages, method of selection, and other pertinent data on two basic types of Pop rivets. **173**

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Methods & Equipment • Testing

Hardness Tester. Wilson Mechanical Instrument Div., American Chain & Cable Co., Inc., 2 pp, illus., No. TT-58. Dimensions, features, operational data and prices of a Rockwell hardness tester. **174**

Hardness Conversion. Babcock & Wilcox Co., Tubular Products Div., 2 pp, No. TCD-183. Chart gives approximate relationship between hardness and tensile strength of carbon and alloy steels. The following hardness systems are covered: Brinell, Monotron, Vickers, Rockwell B, C, and E scales, and Scleroscope. **175**

Processing X-Ray Films. Eastman Kodak Co., X-Ray Div., 6 pp, illus. Describes an entirely new system of faster, better processing for industrial X-ray film. **178**

Induction Heating. Lepel High Frequency Laboratories, Inc., 12 pp, illus., Vol. 1, No. 6. Information on the use of induction heating equipment in zone refining, zone leveling and crystal growing. **179**

Measuring Surface Roughness. Micrometrical Mfg. Co., 12 pp, illus., No. 600. General characteristics, specifications, advantages and other data on a line of equipment used to measure surface hardness. **180**

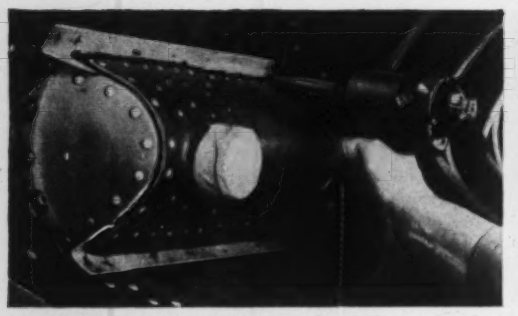
Electric Furnaces, Kilns. Pereny Equipment Co., 8 pp, illus, No. 570. Information on electric heat treating, melting and sintering furnaces, and electric ceramic kilns. **181**

Temperature Indicators. Tempil Corp., 1 p, illus., No. 5910TS. Information on a complete line of available temperature indicators, including instructions for use. Covers such things as checking temperatures of rotating parts, visibility on brightly radiating hot surfaces, and effects of reducing atmospheres in electrical fields. **184**

Testing Materials. United States Testing Co., Inc. Two pamphlets, Nos. 1 and 2 of a series, describe the latest in testing, research, development, design and instruments for materials, components, systems and products. **185**

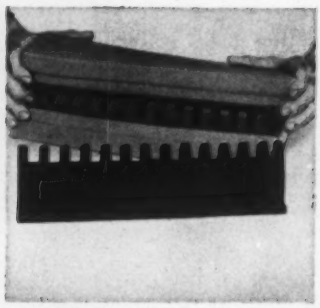
General Electric RTV silicone rubber

New liquid rubber cures without heat, useful from — 70 F to + 600 F, ideal for sealing, electrical insulation and flexible molds.



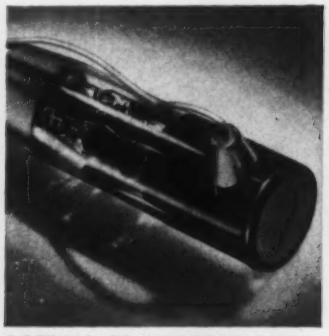
HEAT RESISTANT SEALING, such as shown on this Douglas DC-8 Jetliner, is made possible with RTV (room temperature vulcanizing) silicone rubber. RTV cures without application of heat; won't shrink (no solvents); forms no voids. It has excellent bond strength, plus resistance to high temperatures, moisture, weathering, ozone, aircraft fuels and solvents.

PRECISION MOLDING of prototype and engineering models and replacement parts is simplified and improved with RTV flexible mold material. G-E RTV's low shrinkage permits close tolerances and fine surface detail.



LOW-COST TOOLING with flexible RTV mold material offers added savings in time and expense. RTV's "built-in" release agent provides easy removal of this epoxy coil-winding form from mold. Total cost reduced 81%, delivery time 90%.

ENCAPSULATION OF STATOR WINDINGS, introduced by General Electric motor departments, extends service life of motors. RTV's resistance to moisture and other contaminants enables these dripproof motors to meet certain applications formerly requiring enclosed units.



POTTING OF AIRBORNE EQUIPMENT provides protection from high altitude arc-over and corona as well as vibration and moisture. RTV silicone rubber protects this cathode ray tube up to 70,000 feet.

RTV COIL IMPREGNATION enables this Hughes Aircraft Co. transformer to provide top performance at 250°. Unlike other insulations tried, G-E RTV compounds proved successful both for coil impregnation and full encapsulation.

For application data and samples of General Electric RTV silicone rubber write Section B614, General Electric Company, Silicone Products Department, Waterford, New York

GENERAL ELECTRIC

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Materials, forms, finishes
. . . and related products . . .

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For free technical literature on all kinds of engineering materials, forms and finishes, see pp 43-47.

HANDY & HARMAN SILVER BRAZING
Permits Manufacturer to Guarantee Underwater Air Regulator For Life

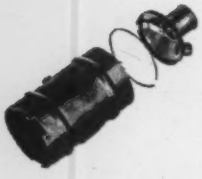
Perhaps the most vital component of a skin diver's equipment, this Viking Air Regulator, manufactured by Christensen Tool & Engineering Company, Norwalk, Connecticut, is structurally guaranteed for life. It must, under all conditions, be absolutely leaktight. The manufacturer's guarantee is a relatively recent achievement—through the high-strength help of silver alloy brazing with Handy & Harman EASY-FLO 45 and HANDY FLUX.

Over and above the unreserved dependability of brazed joints, the brazing method itself has saved the company considerable time, money and material in the production of the Viking Air Regulator. Brazing's simplicity is interestingly illustrated in this case by this company's requirement that assemblers and testers of the Viking must be skin divers themselves.

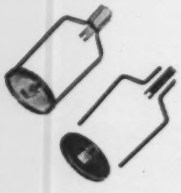
Almost invariably, silver brazing effects economies and brings advantages to whatever part, product or assembly it is applied. True, air regulators are few and far between, but the point is that they are *metal products, made of a number of different metal components.*

And that's the phrase that covers brazing's great adaptability. To give you a good idea of how you can put brazing to work, we'd like to send you Bulletin 20—it covers the basics of brazing and it may very easily solve your metal-joining problems. Handy & Harman, 82 Fulton Street, New York 38, N. Y.

Here, in "serial" form is how the guarantee is "brazed" into the Viking:

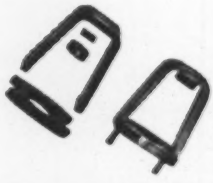


1. TANK HOUSING—Initially, this component was mechanically joined and made "airtight" by means of sealants. Now, brazing eliminates 8 holes, 4 tapping operations, 4 screws and 3 assembly operations.



2. FORK ASSEMBLY—There are five separate brazed joints, done with hand torch and hand-fed wire. Brazing eliminates one tapped hole, a lock washer and a spacer, plus the fact that positive alignment is now guaranteed.

5. Shown here are the finished Viking components before and after assembling. —Brazing by Specialty Brazing Laboratories, Riverside, Connecticut.



3. YOKE—This is assembled from stampings instead of castings, which were previously used. With brazing, no secondary finishing operations are required. Further, the part is stronger and lighter, and savings on material and labor on this component alone add up to 28%.

4. PISTON—This is the most important single element of the Viking. It regulates flow of oxygen from cylinder to mouthpiece; from 300 lbs. pressure to normal breathing. Without brazing, this part could not be made.

Your No. 1 Source of Supply and Authority on Brazing Alloys

HANDY & HARMAN

General Offices: 82 Fulton St., New York 38, N. Y.

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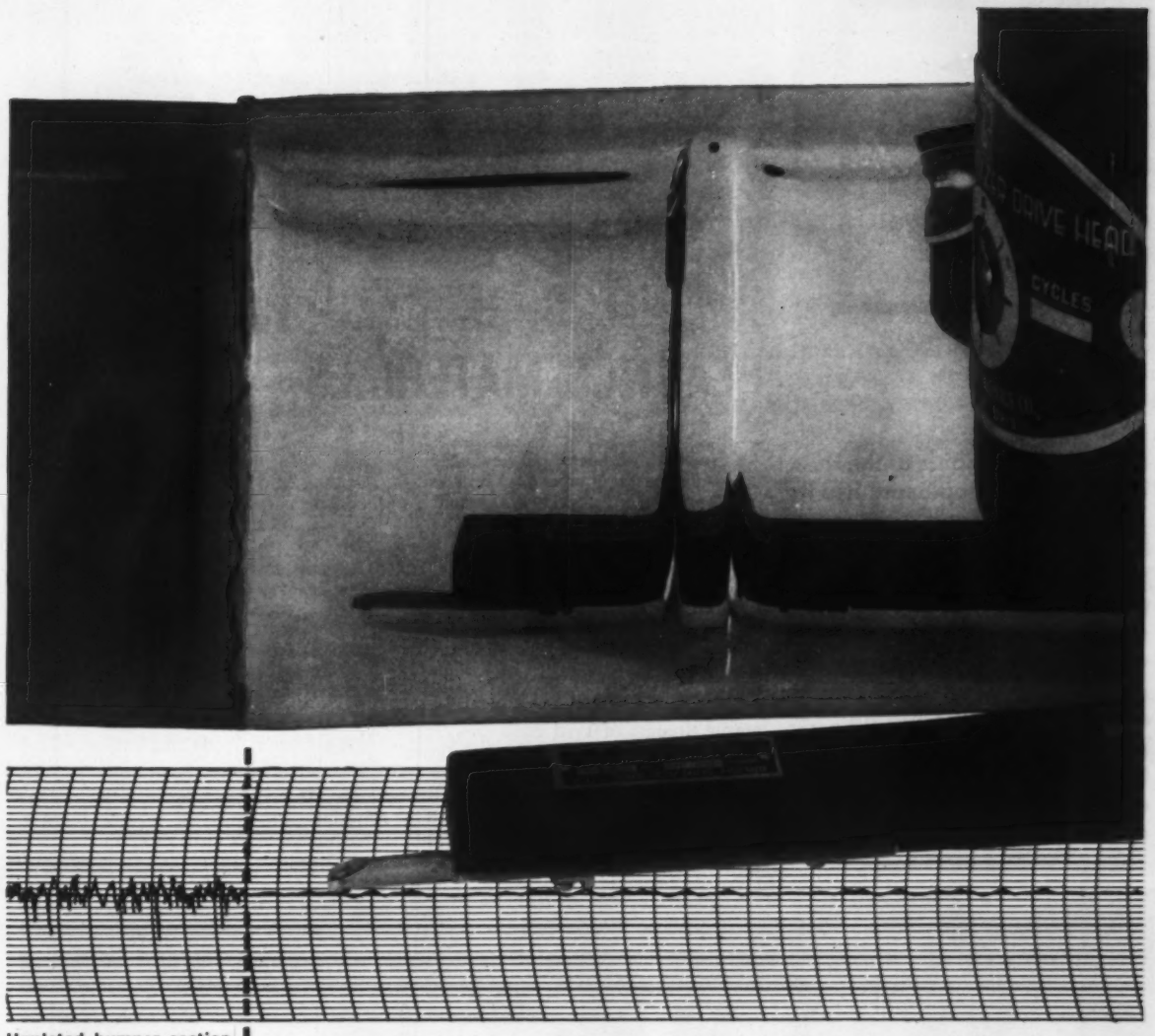

Unplated bumper section shows surface variations averaging 40 micro-inches.

Same bumper section plated with 2 mils of leveling Nickel and 0.01 mils of chrome shows an average variation from level reading of no more than 5 to 6 micro-inches.

See how a layer of leveling Nickel takes polishing-buffing costs out of plating

Above, you see how a layer of leveling Nickel can be used on bare steel to even out surface imperfections, reducing the need for polishing and buffing before and after plating.

The leveling Nickel, however, could have been applied to a zinc, brass or aluminum part or product with equally good results

Special Nickel baths have been developed to coat and smooth the rough surfaces of a wide range of basis metals. By employing these baths, engineers and designers can reduce, in many cases *eliminate* high polishing and buffing costs.

You get higher quality, too. Leveling Nickels, when plated semi-bright, are often coated with bright Nickel before chrome plating. The thick, double-layer Nickel coating that results assures high brightness and lasting beauty. It provides a mirror-smooth, white-metal foundation for a brilliant blue-white finish. It backs up the chrome and cushions it against cracking—protects basis metals from rust and corrosion.

So with Nickel in ample supply as far into the future as any man can foresee, you can now plan to use leveling Nickel Plating to cut your production costs and enhance plating quality.

For more information about versatile Nickel coatings, write us for our informative booklet, "PRACTICAL ANSWERS TO 40 PRACTICAL QUESTIONS ABOUT NICKEL PLATING."

The International Nickel Company, Inc.
67 Wall Street New York 5, N.Y.

INCO

Inco Nickel

Nickel makes plating perform better longer

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DOW

NEWS ABOUT PRODUCT DESIGN AND MATERIALS

The happy marriage of modern plastic materials and mass production techniques has been a boon to product designers. With economical production methods assured at the outset, they have been able to take many new and original plastics materials from the research labs of Dow and blow, squeeze, mold and extrude them into products with built-in durability, color appeal, and the "tomorrow" look. Here are some ideas . . .

DESIGN AROUND HEAT, IMPACT, CHEMICALS, WITH DOW PLASTICS MATERIALS

Each of the members of the Dow family of thermoplastics has its specialties . . . and each member's specialties can be further compounded into formulations that highlight one or more strong features. The result: A wide range of highly specialized plastics with such features as economical production . . . high impact strength . . . high heat resistance . . . exceptional moldability. Take fan wheels molded of Tyril® for instance . . .

An excellent balance of physical properties—with special emphasis on high critical elongation and good heat resistance—qualify Tyril for the vigorous, on-the-job performance requirements of a condenser fan wheel.

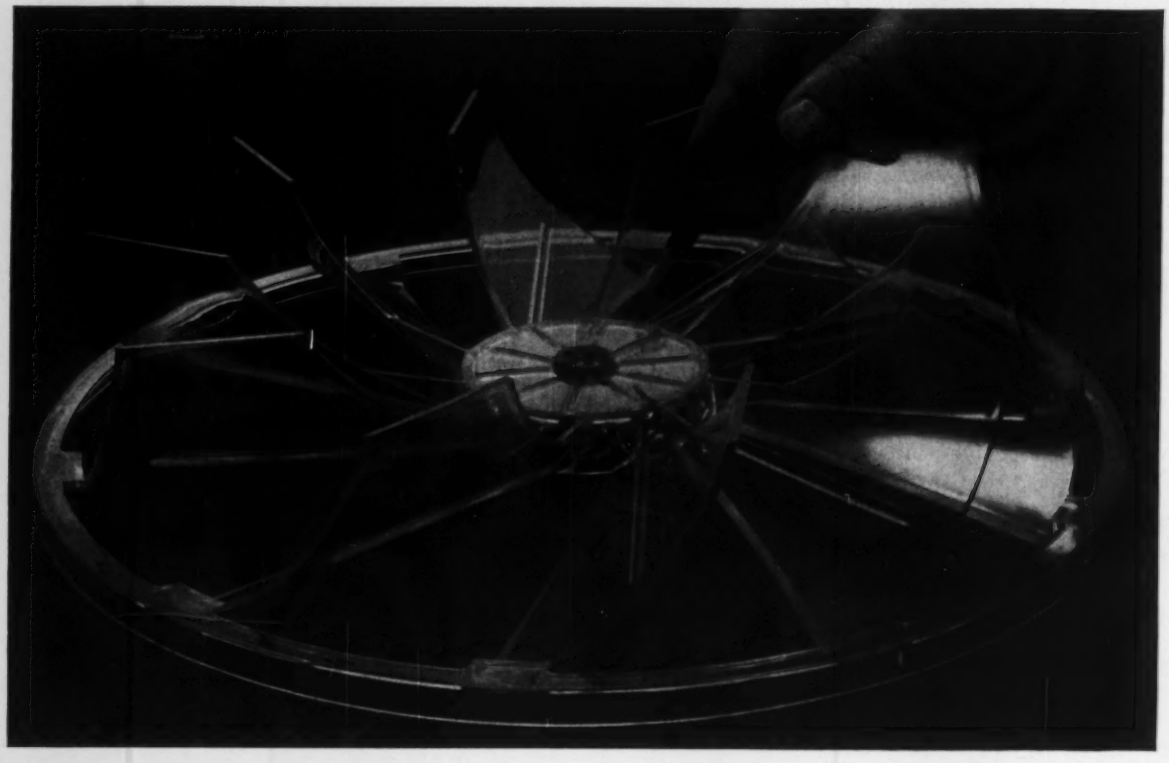
A Dow copolymer of styrene and acrilonitrile, Tyril provides the exceptional molding characteristics required to reproduce the complex configurations, reverse curves and angles of the mold; and to maintain the high axial accuracy of the fan wheel in operation. The high tensile strength of Tyril minimizes creep and cold flow. And in production, faster cycling and better moldability result in marked economies for the manufacturer.

Heat resistance, too, is an important feature of Tyril in this and other applications. In fact, by successfully withstanding the high temperatures of a condenser housing, this fan wheel made of Tyril has the approval of the Underwriters' Laboratories.

The outstanding performance characteristics of Tyril are currently making it the favored Dow thermoplastic for such products as tumblers, cutlery handles, bristles, filter bowls, rigid food containers, closures, pencil barrels, medical equipment components, and sprayer heads.

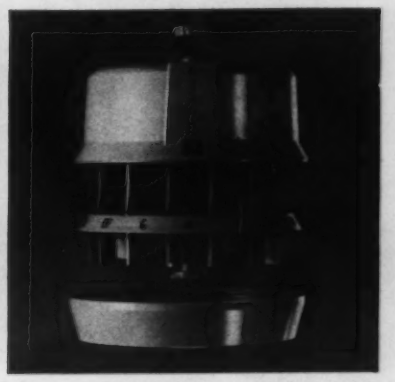
Mouth-to-mouth resuscitation takes a giant step forward with the introduction of this unique mouth-to-mask resuscitator. This handy device relies on the special properties of several thermoplastic materials in its design.

Fan wheel of Tyril meets manufacturers' requirements for moldability; U.L. requirements for safety.



Resuscitator relies on a variety of plastics.

Lint filter of heat-, chemical-resistant Styron 440.



Rotary card file of shock-resistant Styron 440.

Both the patient's and operator's mouthpieces are molded of Styron® 440 to take the hard knocks of emergency use and for the good fabricating qualities of this plastic material. The resuscitator tube and the catheter tube are of vinyl formulations. The "airway" for keeping the patient's throat clear is molded of tough moisture- and chemical-resistant polyethylene. And the aspirator jar is also molded of Styron 440, a high-impact, high-heat resistant formulation.

When washday rolls around, this same versatile formulation – Styron 440 – is ready, willing, and able to meet the challenge of today's automatic washers. Lint filters and other parts molded of Styron 440 have the extra tensile strength to withstand years of rugged service . . . the chemical and heat resistance to shrug off effective laundry detergent, and high water temperatures.

Another example of versatile Styron 440 in action is the rotary card file above. Styron 440 gives it extra impact strength. It won't warp, nor will rough treatment affect the appearance of the tough, lustrous case. Inside, ribbed separators keep the cards in order . . . ribs that can be formed accurately thanks to the excellent moldability of Styron 440.

Everyone's an old master when he rolls up his sleeves and goes to work on a numbered oil painting set. The latest of sets has individual paint jars molded of Tyril. This rigid material was selected for its ability to reproduce fine details—especially in the molding of the screw-top threads and grooved bases of the paint jars.

Other characteristics of Tyril make it the ideal thermoplastic material for a car compass housing. Tyril meets the tests for ruggedness and nonmagnetic qualities . . . and it is resistant to chemicals and distortion over a wide temperature range.

The aristocrat of plastics, Ethocel®, has been elected by the manufacturer of these accurate, low-cost split image transits. Extremely high impact strength for rugged service, and superior dimensional stability that keeps the lens accurately positioned in one place were the recommendations for Ethocel in this application.

Individual paint pots are molded of Tyril.

Low-cost transit protected by Ethocel.

Compass housing of rugged Tyril.

HOW ABOUT IT? Have you taken a close look at your products lately in terms of (1) the new and original plastics from the research labs of Dow, (2) the new formulations and applications of the established Dow plastics, or (3) the new economies in production techniques? An examination today might mean greater sales appeal and more efficient production tomorrow. If we can be of any assistance—from selecting the right formulation for your product, to assisting you in color styling—please write The Dow Chemical Company, Midland, Michigan, Plastics Merchandising Department 1719CD6.

THE DOW CHEMICAL COMPANY
Midland, Michigan

DOW

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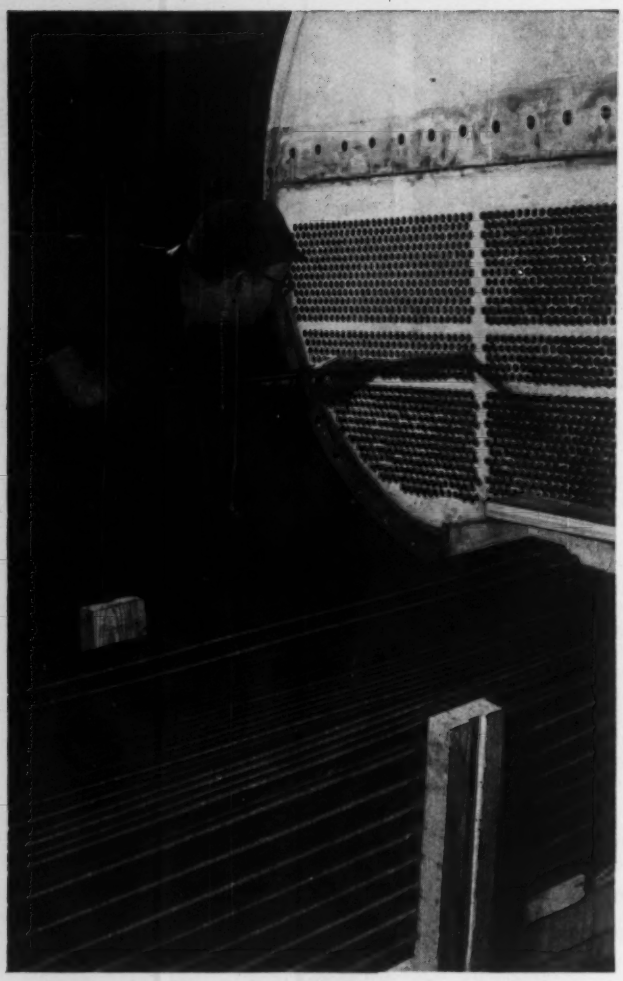

York counts on WOLVERINE TRUFIN® for Quality and Maximum Heat Transfer

In Atlanta, Ga., customers of Rich's Department Store shop in air conditioned comfort—thanks to air conditioning equipment manufactured by York Division of Borg-Warner Corporation, York, Pennsylvania.

And, like countless other air conditioning installations made each year by York, this one too, uses integrally finned Wolverine Trufin Type S/T condenser tubes in its heat exchangers.

Of Wolverine Trufin and its ability to increase heat transfer capacity, York engineers say, "Quality materials are as necessary as the skilled workmanship that goes into every York product. We find that Wolverine Trufin's extended surface gives us a good ratio of inside to outside heat transfer. It permits the maximum amount of heat transfer with a minimum of space while maintaining outstanding dependability."

If your company requires nonferrous tubing for heat transfer—or any other purpose—talk to Wolverine Tube before placing your next order. Like York Division you'll find the kind of quality and dependability that meets your highest expectations. Write, too, for your copy of the Wolverine Tubemanship Book.

WOLVERINE TUBE
DIVISION OF
Calumet & Hecla, Inc.
DEPT. B, 17258 SOUTHFIELD RD., ALLEN PARK, MICH.
Manufacturers of Quality-Controlled Tubing

J-8783

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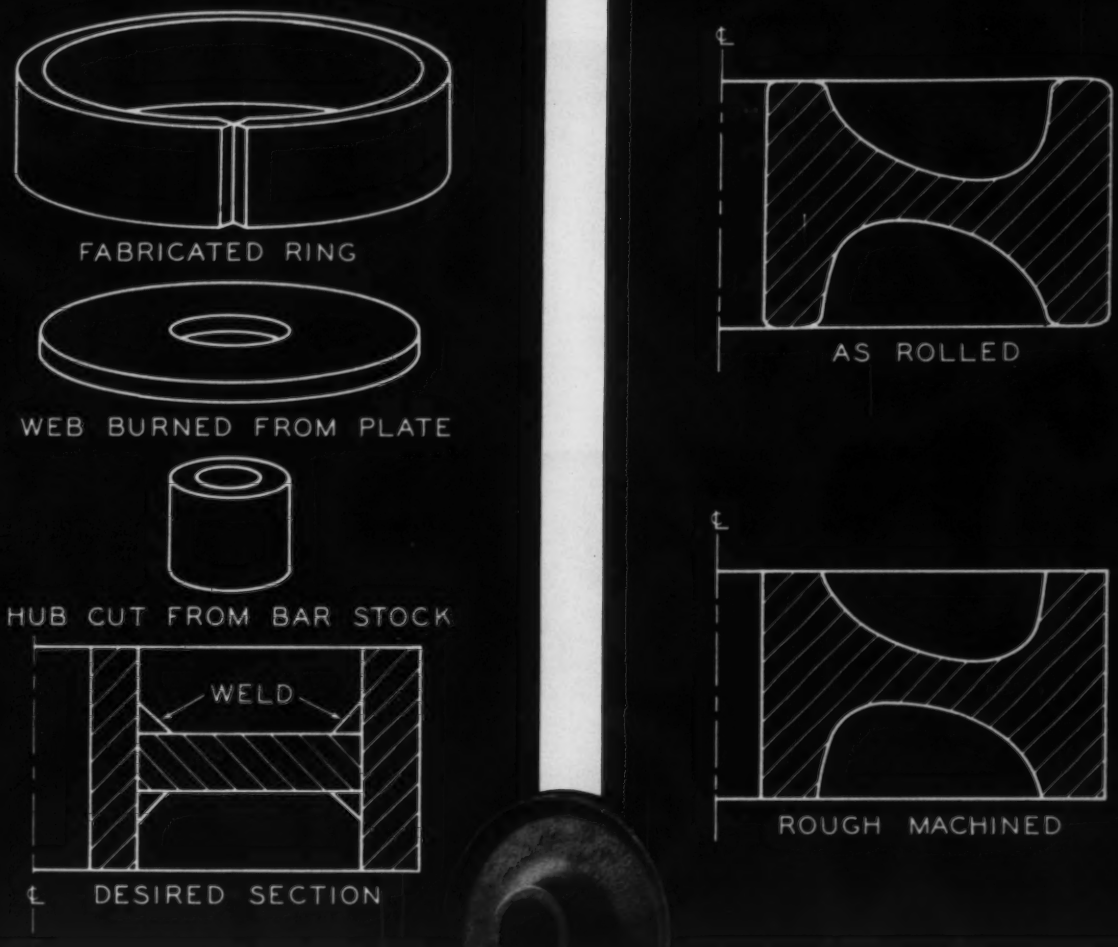

Why fabricate it?

(and pay for waste metal, assembly time, welding?)

Bethlehem Circular Forgings come ready for finish machining. Unlike a weldment, there's no fabricating to be done. No assembling. No welding. You save the high cost of all those operations—and the cost of the metal those operations waste.

Cost? Thanks to our Slick Mill (the only one of its kind in the country), the cost of Bethlehem Circular Forgings is low. Even if new tooling is required, orders of 20 or more pieces are economical (dies can be changed in just 15 minutes). Our mill forges and rolls an impression-die forging in about one minute. Because contact time between die and work is so brief, and because there's no impacting, low-cost dies can be used.

We'll forge it!

(and cut your costs: less metal, no assembly or welding)

There you have it. One, important fabrication savings. Two, low initial price. That's why forged circular products consistently cost less than weldments.

Bethlehem Circular Forgings are available in carbon, alloy, or stainless steels, and some heat-resistant grades. 10 to 48-in. OD. 100 to 2,000 lb. As-rolled or rough-machined to specifications. For full details, call or write the Bethlehem sales office nearest you.

BETHLEHEM STEEL COMPANY, BETHLEHEM, PA.
Export Distributor: Bethlehem Steel Export Corporation

BETHLEHEM STEEL

BETHLEHEM STEEL

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PLASTICS
in Design
Engineering

New Teflon* FEP resin enables Garlock to supply mechanical and electrical parts of complexities never before achieved.

New developments in TEFLON FEP shapes and parts by Garlock. With the commercial availability of Teflon FEP, Garlock can now fabricate mechanical and electrical components never before possible with Teflon TFE. The reason is this—whereas TFE must be processed like powdered metals, the new FEP has the advantage of being melt-processed in conventional extrusion and injection molding equipment.

Think of what this means to you as a designer. You can now specify Teflon for the most delicate and complex shapes you may design. Teflon FEP opens whole new avenues of design possibilities . . . parts of the most intricate shapes . . . wall sections of minimum thinness of .020″-.030″ . . . pieces with the closest of tolerances. Garlock also furnishes Teflon FEP in rod stock for ready cutting and machining.

Another important point. Developed as a supplement to Teflon TFE, the new FEP resin exhibits the same fine physical properties of chemical inertness, top thermal stability, excellent dielectric strength, and outstanding anti-stick and frictional characteristics. FEP is rated at a continuous service ceiling of +400°F, will resist extreme cold down to −395°F.

At low temperature, FEP has more impact resistance than any other known plastic. It is virtually unaffected by weather and remains unchanged when subjected to ultra-violet light and ozone attack. Finally, water absorption of FEP is zero!

Turn to Garlock—and their years of experience in fabrication of plastics—for more information on stock shapes and intricate parts of new Teflon FEP. The Garlock representative serving you will be glad to give you complete details. Call him at the nearest of Garlock's 26 sales offices throughout the U.S. and Canada. Or, write for catalog, Garlock Inc., Palmyra, New York.

GARLOCK

Canadian Div.: Garlock of Canada Ltd.

Plastics Div.: United States Gasket Company

Order from the Garlock 2,000 . . . two thousand different styles of Packings, Gaskets, Seals, Molded and Extruded Rubber, Plastic Products

*Du Pont Trademark for TFE and FEP resins

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METALLURGICAL RELIABILITY, a function of man and his control of materials and machines. Here at WAIMET we have little that is unique in the world except our dedication to metallurgical science and our unusual ability to tailor alloys to particular end uses. Every day we forge another little wedge, add another small contribution to the knowledge of how metals behave. Here are three alloy improvements that are currently aiding users of high temperature alloys:

17-4 PH

Research, in the field and at home, was the key to improving the reproducibility of 17-4 PH castings. The work of the WAIMET technical team resulted in new guaranteed properties and better knowledge of heat treating requirements.

SUPER 3 and 6

Users of cast abrasion-resistant alloys now have the price advantage (up to 40% lower alloy cost) of WAIMET's new chrome-cobalt-tungsten alloys, SUPER 3 and SUPER 6.

WI-52

In eighteen months of intensive effort, WAIMET brought a promising alloy from its state of marginal reliability up to a degree of reproducible performance not anticipated in the original alloy development.

Do you have alloy casting problems, or casting application problems? Perhaps one of these three outstanding alloys - or others of the RxMET® family of high performance alloys will solve your need. Write us for more information.

WAIMET ALLOYS CO.
5320 OAKMAN BLVD.
DEARBORN 2, MICH.
LUzon 1-7200

CASTING ALLOYS · WELDING ROD · MASTER ALLOYS · FORGING BILLETS

For more information, turn to Reader Service card, circle No. 488

DAPON (diallyl phthalate) RESIN GIVES A LIFETIME SHRINKAGE VALUE OF .001 IN THIS AMPHENOL CONNECTOR

This connector routes many circuits in the Bell System's multi-line "Call Director" at a great saving of space and weight.

About the size of a cigarette lighter, an Amphenol-Borg Electronic Corporation connector is used in the Bell System's "Call Director." This versatile telephone can handle as many as 29 outside lines or extensions. The working members of this connector are fifty gold plated bronze contacts held firmly in a body molded from DAPON (diallyl phthalate) Resin.

Chosen by Amphenol for this application because of its dimensional stability and insulating properties, DAPON's superior moldability accommodates the thick and very thin sections and lateral cavities of the connector's body. DAPON molds easily around metal inserts; there is no cracking and little or no after-shrinkage of DAPON molded parts after years of service, even under elevated temperatures.

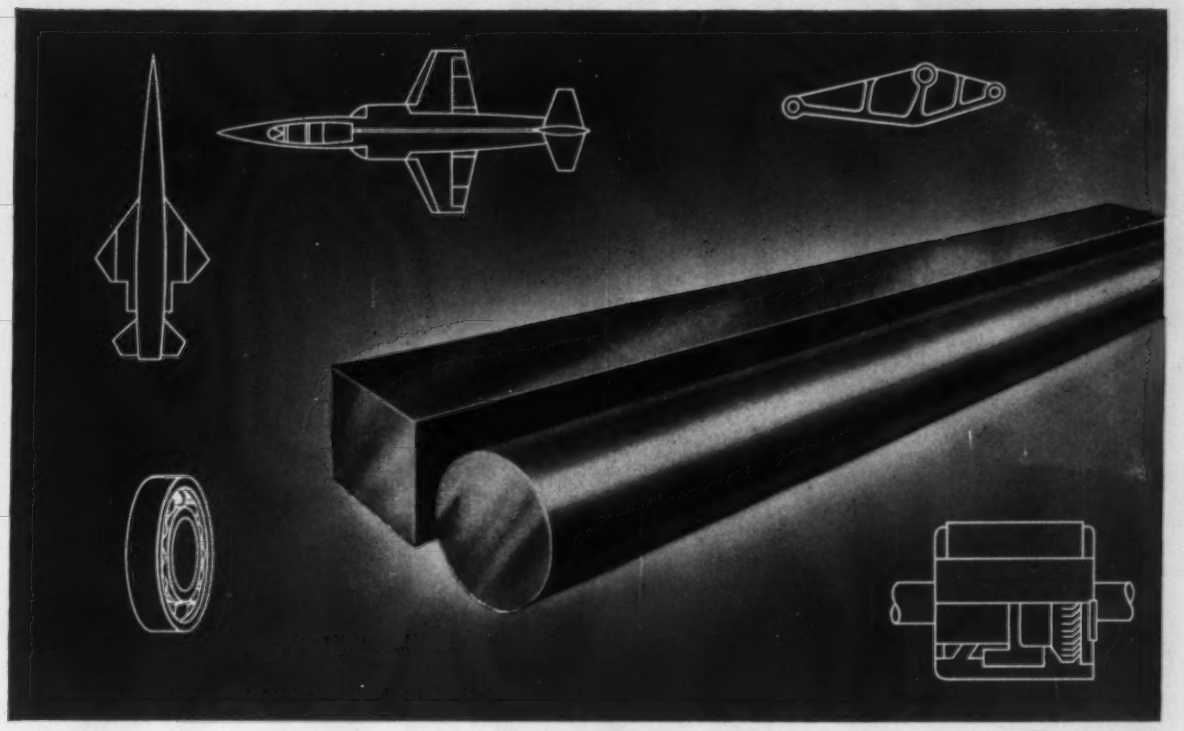
Specify DAPON (diallyl phthalate) Resin when you need:

- Low dielectric loss
- High dielectric strength
- Superior dimensional stability
- Excellent arc resistance
- High volume and surface resistance after high humidity-high temperature conditioning

Write to the address below for FMC's data sheet containing technical information about DAPON, suggested uses for this resin, and the name of the DAPON compounder nearest you.

FOOD MACHINERY AND CHEMICAL CORPORATION
Dapon Department
161 East 42nd Street, New York 17, New York

For more information, turn to Reader Service card, circle No. 457



DEPENDABLE VAC-ARC® Steels

. . . for applications requiring high ductility and tensile strength up to 285,000 psi.

Compare these data . . .

TRANSVERSE TENSILE PROPERTIES 8" square billet of VAC-ARC DYNAFLEX		
Property	*Mid-Radius*	*Center Area*
Tensile Strength (psi)	287,000	285,000
Yield Strength .2% (psi)	252,500	250,000
Elongation %	8	8
Reduction of Area %	25	24

Literature available on all Vac-Arc grades upon request . . . Send today!

Where design demands uniform high strength, toughness and ductility at both low and elevated temperatures, Vac-Arc Steels more than meet the requirements. These steels—produced by Latrobe's consumable electrode vacuum melting process—possess superior cleanliness, lower gas content, improved ingot structure and desirable longitudinal and transverse mechanical properties.

The following grades of Latrobe's Vac-Arc steels are available in a range of sizes and shapes: Pandex (Type A-286) for high temperature applications; MV-1 (Type M-50) and Regent (Type 52100) for critical bearing design; Dynaflex (Type H-11) for aircraft and missile components; AGT (SAE 9310) for carburized aircraft gears.

Many grades of Vac-Arc steels are being produced to meet particular application requirements. Send us your specifications or call your nearest Latrobe representative for *experienced* technical assistance.

Skillfully made in U.S.A. by

LATROBE Metalmasters

LATROBE STEEL COMPANY

LATROBE, PENNSYLVANIA

Branch Offices and Steel Service Centers:

BOSTON • BUFFALO • CHICAGO • CLEVELAND • DAYTON • DETROIT
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For more information, turn to Reader Service card, circle No. 394

TWO NEW SOLUTIONS FOR "HOT" WIRE PROBLEMS ...FROM YOUR SILICONES MAN

Two new low shrink silicone rubber insulating compounds... developed by the UNION CARBIDE Silicones Man... are now solving many of today's electrical wire and cable insulation problems. Offering good dielectric and physical properties with easy processing, they are ideal materials for air frame applications, motor truck wires, motor leads and hook-ups, small appliance wiring, and marine wiring.

UNION CARBIDE K-1347 Silicone Compound is a premium quality stock that meets tight military and industrial specifications. It has high green strength, remilling is easy, and it is readily colored for coding. Easily extruded, it provides a smooth, non-porous, high gloss surface, and can be braided without postcure. Physical properties are excellent using either steam or hot air cures.

For economy operations where good, but not premium, physical properties are needed, lower cost UNION CARBIDE K-1357 may well fill all requirements. Available precatalyzed in both slabs and coiled strips, it can be fed directly from carton to extruder on most equipment.

Both silicones have outstanding retention of tensile strength and elongation after prolonged exposure to high temperature. Both have dielectric strength of 1000 volts/mil. Both can be cured with either steam or hot air. And both are low shrink compounds. K-1347... for premium properties. K-1357... for economy.

For more information, write or call your UNION CARBIDE Silicones Man, or Dept. FM-9905, Silicones Division, Union Carbide Corporation, 30 East 42nd Street, New York 17, N. Y. *(In Canada:* Bakelite Company, Division of Union Carbide Canada Limited, Toronto 7, Ontario.)

Unlocking the secrets of silicones
Rubber, Monomers, Resins, Oils and Emulsions

UNION CARBIDE SILICONES

"Union Carbide" is a registered trade-mark of UCC.

For more information, turn to Reader Service card, circle No. 441

For more information, circle No. 330

LIGHTER WEIGHTS FOR A **HEAVIER PROFIT**

Order a ton of stainless steel sheets and you receive a ton of stainless steel. But the square footage of that steel can differ.

Eastern's precision rolling holds the gauge toward the light side of recognized tolerances . . . actually delivers more area of stainless per ton. Result: Since you sell by the square foot, you earn more dollars per sale.

There's a profit in precision rolled stainless from Eastern.

EASTERN

STAINLESS STEEL

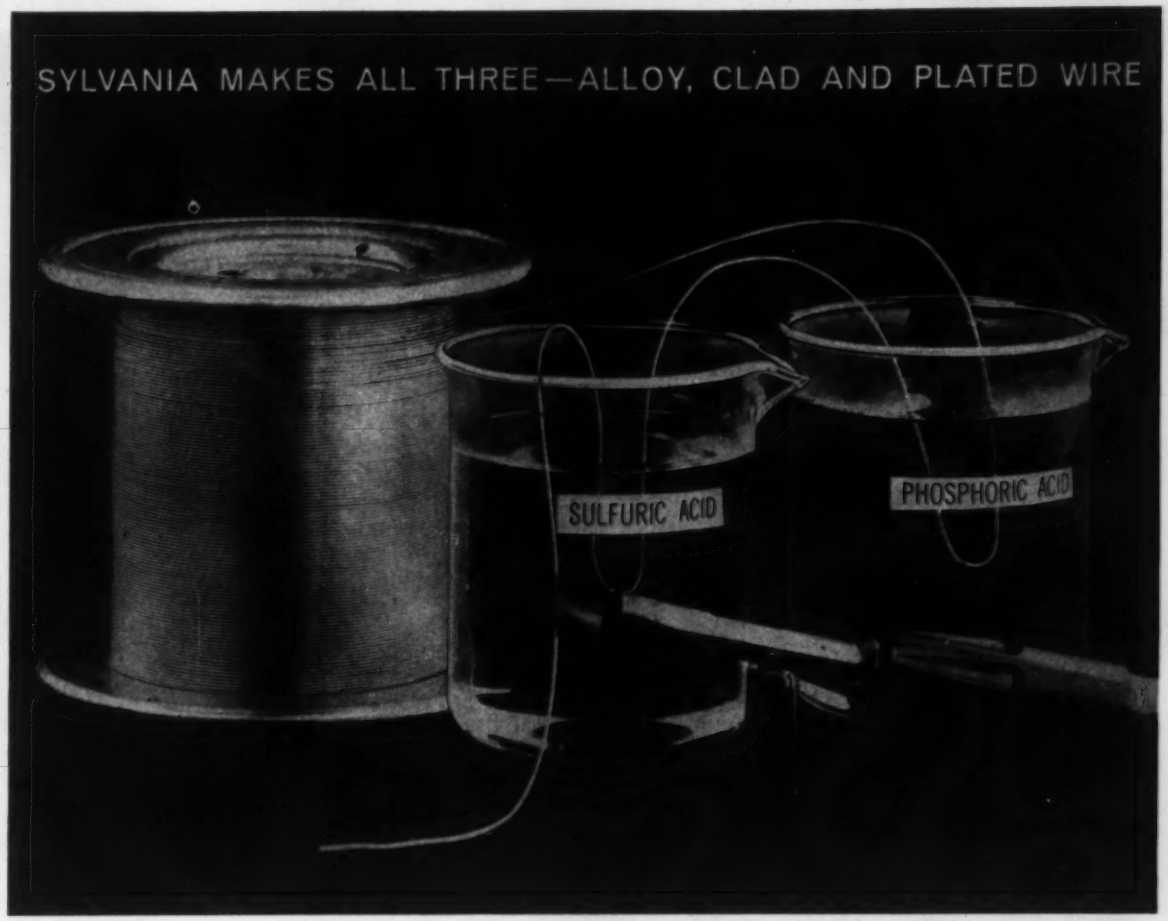
BALTIMORE 3, MARYLAND, U. S. A.
stainless steel sheets, plates, strip, coils

Tempilstik°. . . temperature indicating crayons

TEMPILSTIKS° are widely used as a standard method of determining temperatures in welding procedures, metal working and heat treating, steam trap maintenance, tire-retreading, plastic forming and hundreds of other heat-dependent operations. Available in 80 different temperature ratings . . . $2.00 each. Most industrial supply houses carry Tempilstiks°. If yours is an exception, then write direct to us for further information.

Tempil° CORPORATION • 132 West 22nd St., New York 11, N. Y.

For more information, turn to Reader Service card, circle No. 433



New Sylvania nickel-clad silver 20% wire passes the acid test—beats the heat

—another reason why Sylvania gives unbiased recommendations on wire

New Sylvania nickel-clad silver 20% wire has all these outstanding properties: excellent electrical conductivity, corrosion resistance superior to silver wire, ability to withstand temperatures up through 1500°F. As a result, it's ideal for electrical hookup wire where conditions call for critical service, long life under oxidizing, corrosive or high-temperature environments.

This new wire is available from .005″ to .125″ diameter, in a variety of tempers from dead soft to full hard.

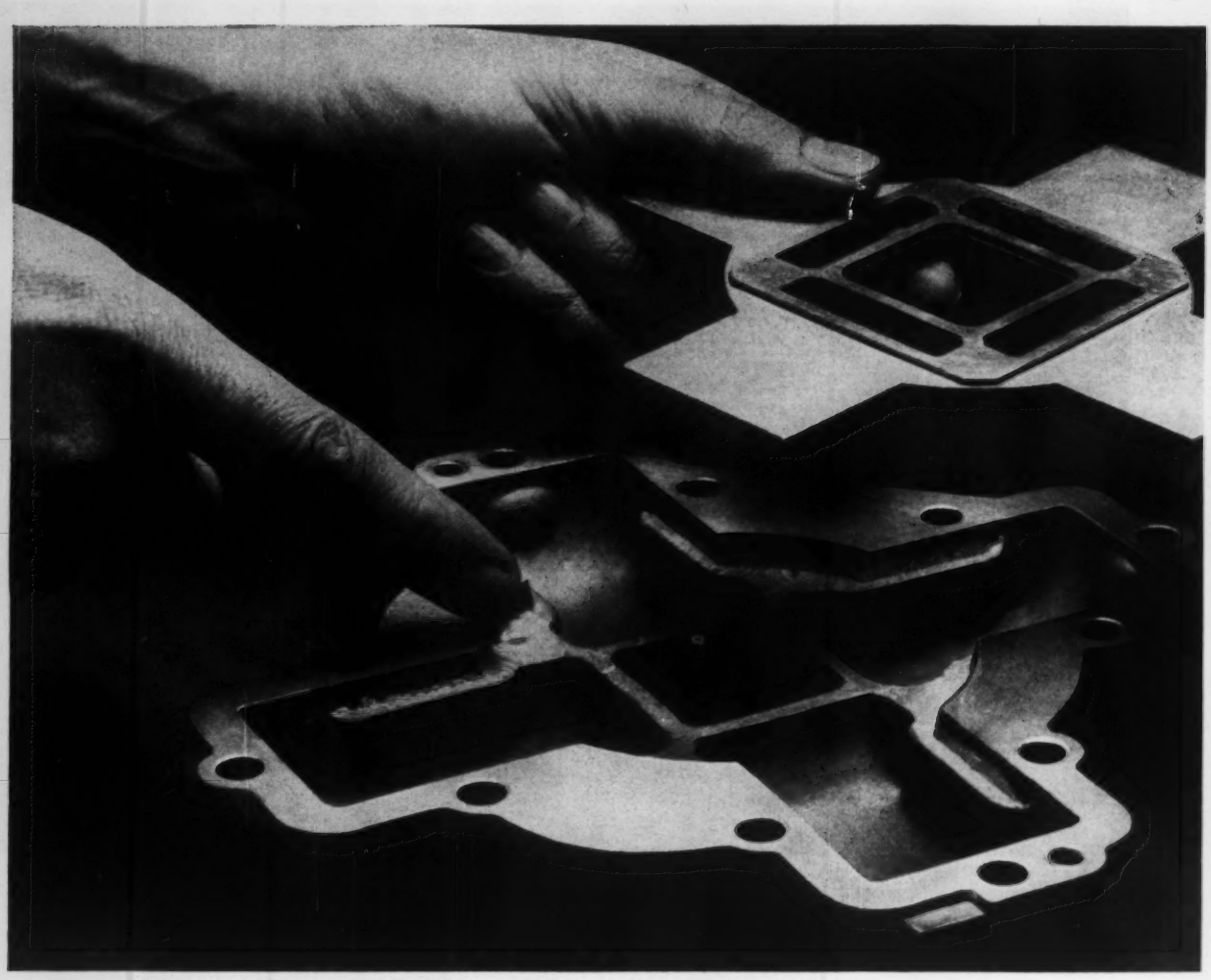
It is another example of how you can simplify your design and specification problems by getting a Sylvania recommendation on wire. Sylvania knows wire, knows the particular advantages of each kind. In fact, of all major manufacturers, only Sylvania makes all three types of bare wire—alloy, clad and plated.

Why not get full details and timesaving technical assistance today. Simply write Sylvania Electric Products Inc., Parts Division, Warren, Pennsylvania.

SYLVANIA

Subsidiary of **GENERAL TELEPHONE & ELECTRONICS**

For more information, turn to Reader Service card, circle No. 338



SEPARATE CASTINGS, bonded together in areas indicated, form complete complex casting shown on the right.

Cut rejects! Fabricate complex castings with

Now you can simplify production of hollow castings —and end costly rejects by casting them in sections, then bonding the sections together with high-strength SCOTCH-WELD Structural Adhesives, such as EC-1386!

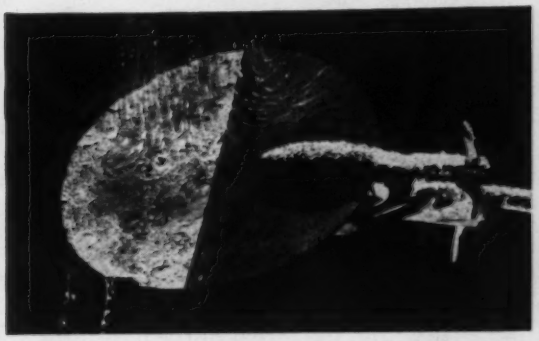
By so doing, you eliminate the high rejection rate that often accompanies sand molding. You eliminate the costly machining and equipment required for mechanical fastening. You eliminate the wasteful, space-consuming bosses or flanges.

All you need is a flow gun and an oven. EC-1386 is a 100% non-volatile liquid and is solvent free. Thus, waste is negligible; no pre-drying is required before joining the sections. The adhesive bond can be cured to high ultimate strength quickly in an air-circulating oven (one to two minutes at 500°F. bond line temperature). And the cured bond can be machined for final touch-up operations. EC-1386 also serves to fill in voids, so that parts need not be held to close tolerances.

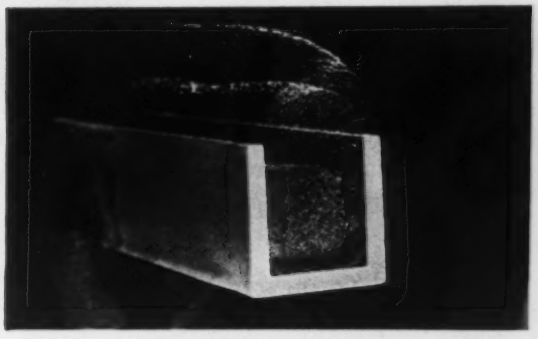
See how EC-1386 can help you cut costs, simplify and speed production and improve product quality. And learn how other 3M Adhesives are helping the metalworking industry. Contact your 3M Field Engineer. Or write: AC&S Division, 3M Company, Dept. SBHH-60, St. Paul 6, Minnesota.

"SCOTCH-WELD" and "CORO-GARD" are Reg. T.M.'s of 3M Co.

News about other 3M products



CORROSION RESISTANT COATING. CORO-GARD® 1706 Brand Protective Coating resists corrosive fluids and fumes, water and abrasion. It passed these torture tests: 2000-hour corrosive salt spray attack; 20-week submersion in 20% solution of hydrochloric acid; 6-month weather exposure in Miami, Florida. For steel, aluminum, wood, concrete, cloth, even some plastics.

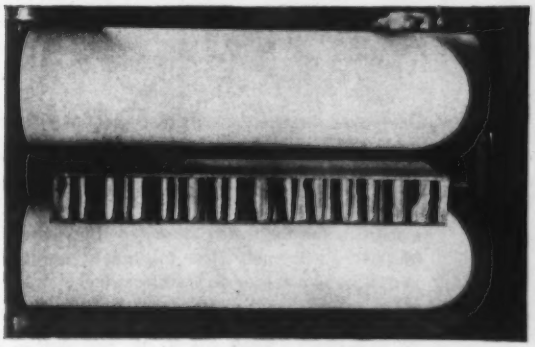


SURE WAY TO SEAL. 3M Heat Expandable Sealers expand up to 125% under the normal heat of a paint-baking cycle, cure to a tough, flexible mass that keeps out dirt, water and weather, completely seal even the most irregular gap or seam. The unexpanded solid is also efficient as a gasket replacement sealer, flange sealer and for other sealing jobs.

SCOTCH-WELD®

BRAND STRUCTURAL ADHESIVES

COLD SANDWICH BONDING. 3M Adhesive EC-1357 makes it possible for you to bond sandwich panels with a nip roller or cold press. You need no clamps or heated presses to complete tough core-to-skin bonds that resist moisture and high and low temperatures. This one adhesive bonds a variety of materials quickly, economically. Its dark color absorbs infrared heat quickly, dries fast.



ADHESIVES, COATINGS AND SEALERS DIVISION

MINNESOTA MINING AND MANUFACTURING COMPANY

. . . WHERE RESEARCH IS THE KEY TO TOMORROW

3M COMPANY

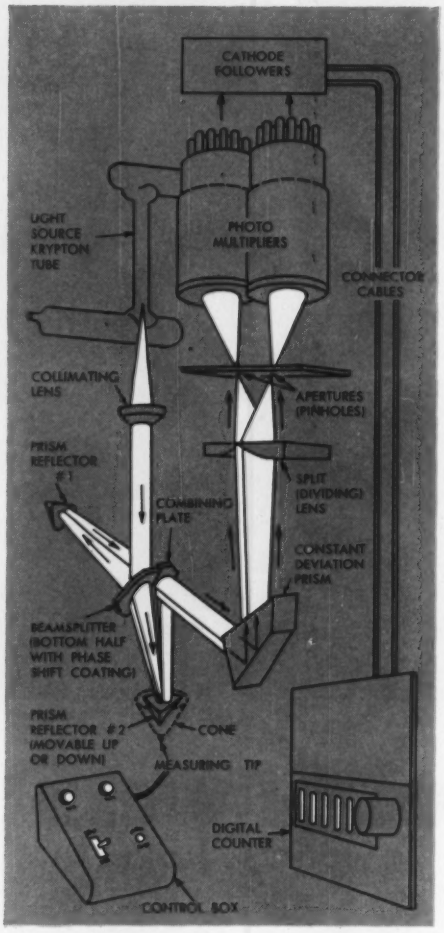
For more information, turn to Reader Service card, circle No. 437

There IS a Difference in STAINLESS STEEL STRIP

...when "tonnage is produced on a laboratory basis"—

At Wallingford, stainless steel strip having close tolerance specifications is thoroughly cleaned before final inspection because contaminants have weight; and non-contact gages measure all weight within the throat of the measuring head. A sample is then taken from the coil, delivered to a temperature controlled room and measured with a Fringecount Micrometer – interferometer, control box and counter – to compare the thickness of the sample to the wave length of a krypton light source.

As the diagram at right shows, the movement of the measuring tip modulates the krypton light source and produces fringes which are detected and counted. This reading is then converted to thickness of the test piece. After measuring, the sample returns to the line; the gaging equipment is zeroed against the known thickness, and processing starts up again. By taking a sample from each coil, ***it is almost impossible to have an error caused by variation in density between different alloys.***



Do your suppliers measure close tolerance stainless steel strip with such exactitude? Why not purchase ***your*** stainless steel strip where ***tonnage is produced on a laboratory basis?***

Facilities for widths up to 27" – thickness down to .001" – extremely close tolerances maintained. Write for new folder on stainless steel strip.

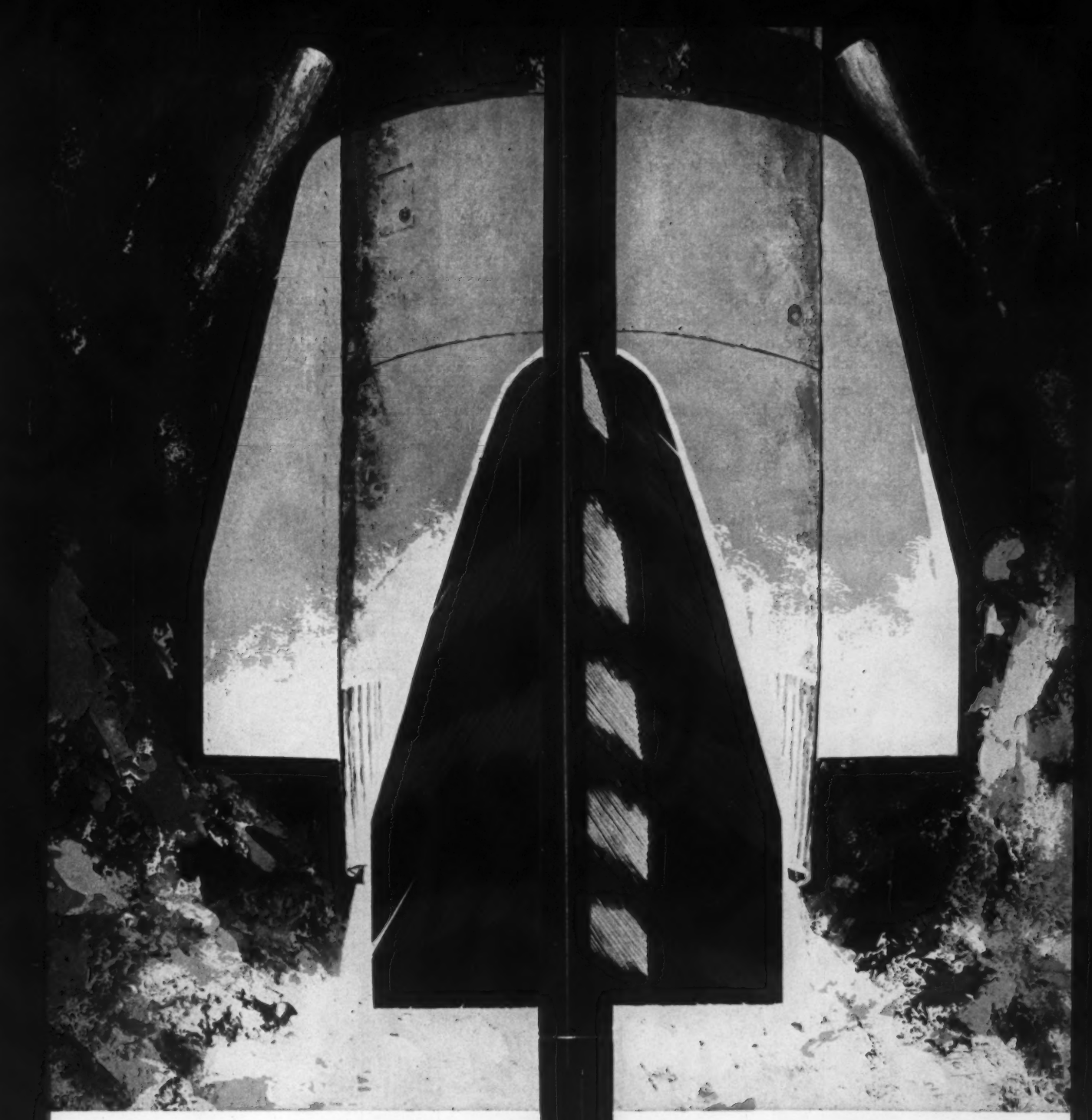
THE WALLINGFORD STEEL CO.

Progress in Metals for Over 38 Years

WALLINGFORD, CONN., U.S.A.

COLD ROLLED STRIP: Super Metals, Stainless, Alloy • **WELDED TUBES AND PIPE:** Super Metals, Stainless, Alloy

For more information, turn to Reader Service card, circle No. 352



Swedlow

MATERIONICS

Stone age profile on a space age missile. But in performance: progress in the science of fabricating advanced materials. In Swedlow language: MATERIONICS. In Swedlow practice: the insight to solve challenging problems of design and producibility of transparent plastic glazing, high temperature reinforced plastics—laminates, complex shapes, difficult parts—suppliers of flame resistant flexible coatings. Write for Facilities Report "Z," to Dept. 10

For more information, circle No. 440

SWEDLOW Inc. / LOS ANGELES 22, CALIFORNIA / YOUNGSTOWN 9, OHIO

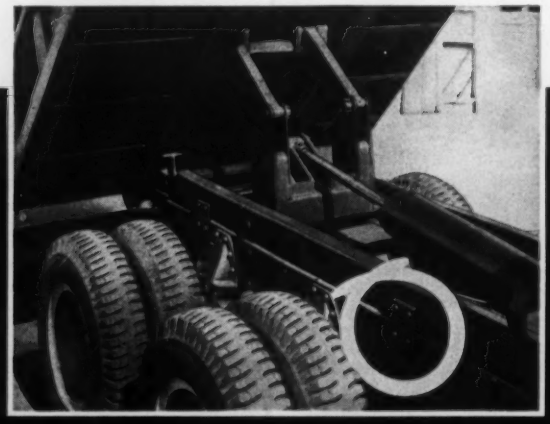
NYLOK NUTS GRAB HOLD... LOCK TIGHT

Vibration and heavy loads can't shake them loose

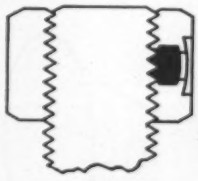
Put tons of load in a dump body, hoist it up, slam it down. Drive the truck over rough, jarring terrain. Still Republic NYLOK® Nuts hold tight—grip with a positive lock to anchor Heil Dump Bodies to the chassis as one solid unit.

NYLOK Nuts stay tight in any position—seated or not. They're easy to apply manually or automatically. Can be used over and over.

Check your products for applications where NYLOK Nuts can do the job better, save you money. Then contact your Republic Distributor. Mail coupon for more data.

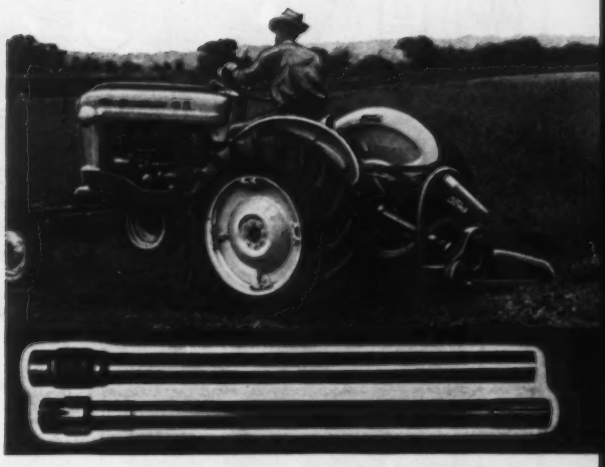


Dump body by Heil Company, Milwaukee, Wisconsin. Unit is anchored to the chassis by 16 Republic NYLOK Nuts.



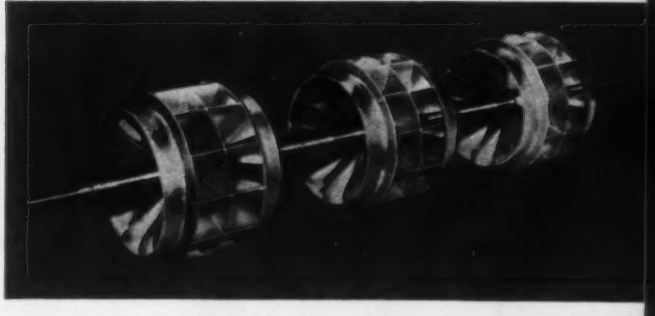
HERE'S HOW NYLOK WORKS

A nylon plug firmly staked into one of the faces of the cold forged hex nut forces a tight, metal to metal contact of opposite mating threads for vibration-proof lock.



POWER TAKE OFF COUNTER-SHAFTS cost Ford Tractor Division less to produce using Republic Die-Form Blanks, as compared with previous materials. Minimum machining is required, handling costs and scrap loss are reduced. Pictured are the blank and completed shaft. Clip and send the coupon for information on the savings potential of Republic Die-Form in your operations.

PAINT STAYS ON. Selection of steel for overhead doors on U.S. Post Office trucks involved two important factors: steel must meet rigid government paint adherence specifications, yet must be economically priced since the manufacturing contracts are on a competitive bid basis. Gerstenslager Co., Wooster, Ohio, chooses *Republic Electro Paintlok®* to meet these requirements. Send coupon for more Electro Paintlok information.



ROTOR SHAFT MACHINING ELIMINATED. Buffalo Forge Company, Buffalo, N.Y., uses *Republic* ELECTRUNITE® *Mechanical Tubing* as rotor shafting in air-conditioning and ventilating unit blowers. ELECTRUNITE's uniform concentricity eliminates need for shaft machining—saves time and money. Shafts are bored at each end and plug inserted for the bearing. Send coupon for more facts on ELECTRUNITE Tubing, stainless, or carbon.

REPUBLIC STEEL

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World's Widest Range of Standard Steels and Steel Products

For more information, circle No. 415

REPUBLIC STEEL CORPORATION
DEPT. MI-9557-A
1441 REPUBLIC BUILDING • CLEVELAND 1, OHIO

Please send more information on:

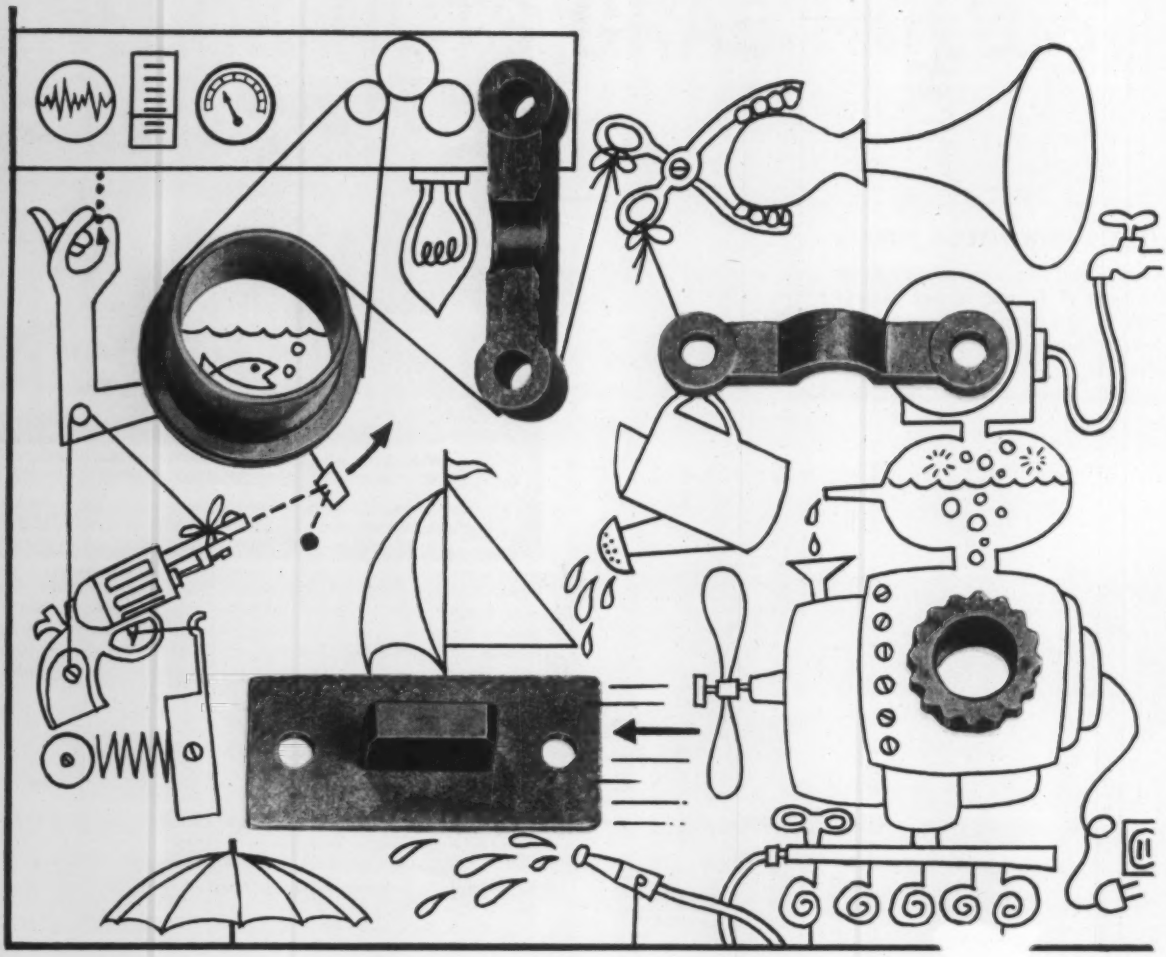
☐ Die-Form ☐ ELECTRUNITE Mechanical Tubing
☐ NYLOK Fasteners ☐ Electro Paintlok

Name_____ Title_____

Company_____

Address_____

City_____ Zone____ State_____



This thing wouldn't run when we plugged it in,

BUT, WE'D LIKE TO SEND YOU THE PIECES*

. . . to introduce you to parts made from superior Glidden Resistox Metal Powders.

You may find that metal powder parts similar to these, or perhaps in entirely different form, can mean substantial savings in manufacture of your products.

Glidden Resistox Metal Powders are prepared by a special process which removes *all* soluble salts, resulting in pure, stable powders for highest finish, appearance and performance characteristics.

Glidden is the world's largest blender and can produce up to 30,000 pounds of powder in a single batch —an important factor in complete uniformity of mass-produced parts.

As a leading supplier of metal powders, Glidden works closely with parts producers. This places the combined training and experience of several staffs of metallurgists and technicians at your disposal.

**Write on your letterhead for sample parts package and further information on powdered metal products.*

QUALITY Glidden PRODUCTS

RESISTOX METAL POWDERS

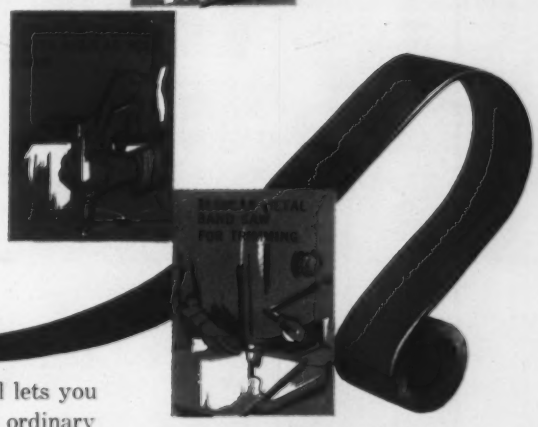
The Glidden Company
Chemical Divisions, Metals Department
Hammond, Indiana

COPPER POWDER • LEAD POWDER • TIN POWDER • BRASS POWDER • ALLOY POWDER • FILTER POWDER
CUPRIC OXIDE • CUPROUS OXIDE • CUPROUS SULFIDE • CUBOND COPPER BRAZING PASTE • COPPER PIGMENT

For more information, turn to Reader Service card, circle No. 424

A first by AllianceWall

porcelain enameled sheets for practical application to vanities and cabinets



Now!! With AllianceWall in its three easy-to-use forms you too can design porcelain enamel surfaces into your products with greater production freedom than ever before.

Available in coils up to several hundred feet in length . . . laminated sheets in sizes up to 4′ x 12′ . . . or in panels laminated to the material of your choice, (cut in sizes to your specifications, if necessary) AllianceWall lets you saw, trim or drill with ordinary production tools *right* on your production line. Select from 28 standard glass-hard, non-fade colors or special colors on request. Let us help you design AllianceWall to your product.

Porcelain enamel AllianceWall gives color fast beauty and lifetime mar-free surface to this beautiful vanity designed by Peter Muller-Munk Associates

AllianceWall

AllianceWall Division, AllianceWare, Inc.
Box 809, Alliance, Ohio

an amp subsidiary

For more information, turn to Reader Service card, circle No. 347

Donald Deskey has been a leader in the industrial design field for more than 30 years. A pioneer in the modern design movement in the United States, Mr. Deskey's influence has helped to bring stability, scope and depth to the profession and is reflected in services rendered to an impressive list of well-known companies.

The Donald Deskey Associates creative staff is one of the largest in the industrial design profession, embracing experts in package and product development, planning, diversification studies, materials research, manufacturing methods and processes, architecture, corporate identification, and marketing analysis.

New Deskey office furniture designs feature mark-resistant patterned

Design versatility is clearly apparent through the combination of Sharon Stainless Steel and Sharonart® in this modern office furniture group by internationally famous designer Donald Deskey.

Colorful, efficient, long-lasting office furniture is the result of combining the beauty of Stainless Steel and the luxurious texture and mark-resistance of Sharonart®.

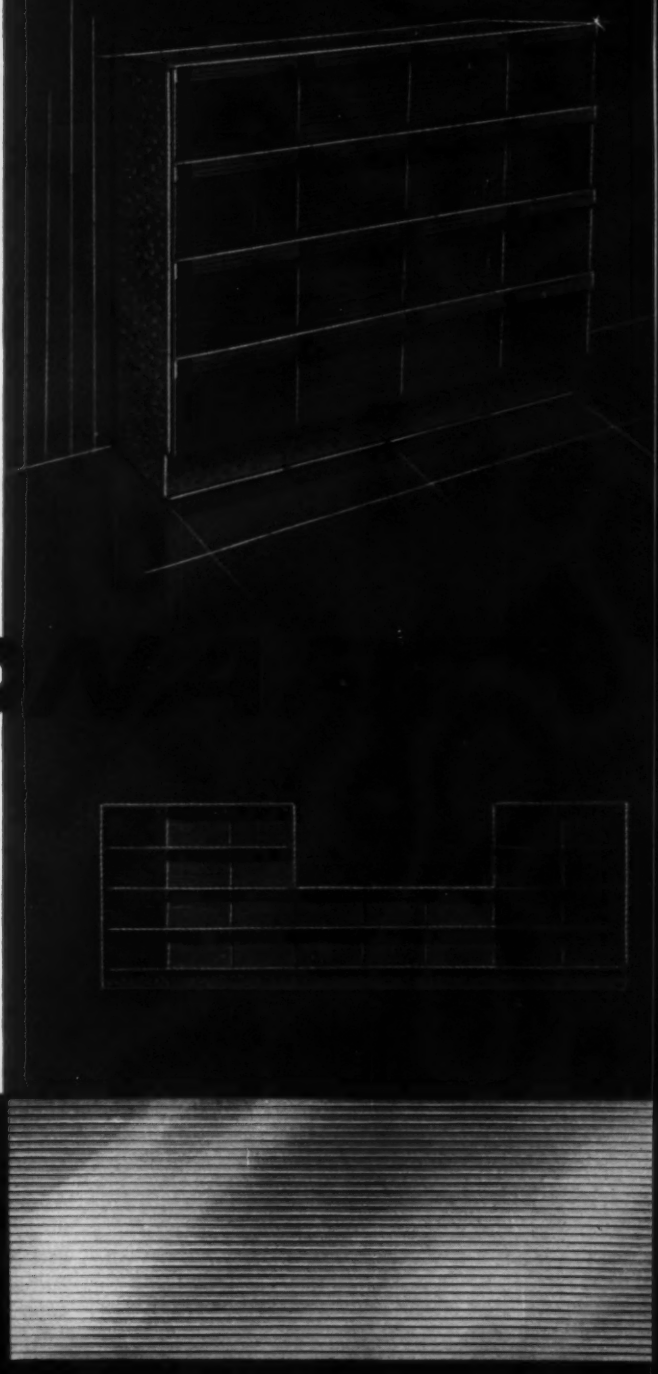
Stainless is available in bright or satin finish, or with Sharonart® patterns.

Sharonart® can be produced in an almost limitless number of patterns. Made of carbon steel, Sharonart® forms easily in standard forming equipment. It can be painted, plated or vinyl coated with beautiful results. For more information on Stainless Steel or Sharonart® write *Sharon Steel Corporation, Sharon, Pa.*

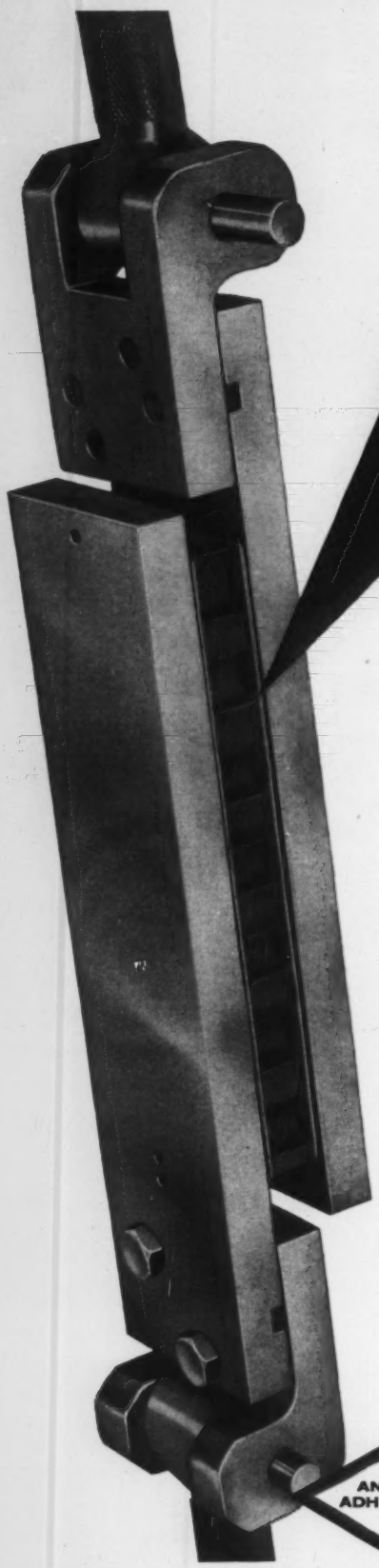
... SHARO

The products pictured on this page are in design form only. They were developed by Donald Deskey Associates, one of America's most respected designers of modern furniture.

For more information, circle No. 431



Steel



ANGIER

CONTACT CEMENTS

SUPERB BONDING AT LOWER COST

FOR YOUR CONTACT LAMINATIONS

Makers of honey-comb or sandwich panels report that Angier Contact Cements deliver an extra measure of both savings and bonding performance.

Easier spraying means greater mileage—a substantial S-T-R-E-T-C-H to your adhesives dollar. Smoother, more uniform films provide better bonding—show excellent resistance to dead load, creep, destructive cycling. Angier-bonded curtain walls have been found to satisfactorily withstand the weather-temperature extremes of northern climate for five years.

Whether for hot or cold bonding, Angier has the *right* contact cement for any type of core and face normally in use. Variations of eight basic formulations provide working properties to meet your particular plant conditions and end uses . . . some even allowing open time up to 1½ hours before nip roll combining.

Angier is a recognized specialist in contact cements. Call on Angier "know-how" and technical service.

NEW BROCHURE—"Custom Formulated Adhesives for Industry" is now available without charge. For your copy, write on your company letterhead to Dept. M-6.

ANGIER ADHESIVES

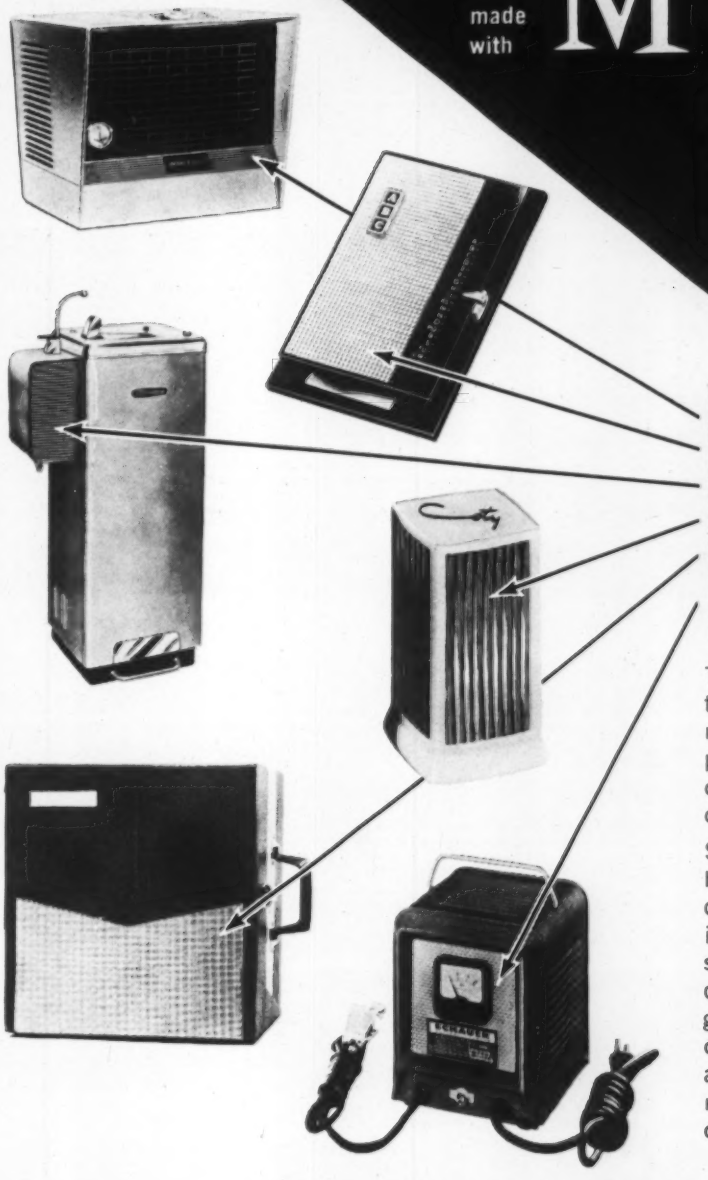
Interchemical
CORPORATION
Finishes Division

Headquarters Office: 224 McWhorter St., Newark 5, N.J. Factories: Chicago, Ill. • Cincinnati, Ohio • Elizabeth, N.J. • Los Angeles, Calif. • Newark, N.J. • Mexico City, Mex. Adhesives plants at: Cambridge, Mass. • Huntington, Ind. *IC and ANGIER are trademarks of Interchemical Corporation.*

For more information, turn to Reader Service card, circle No. 324

PRESSURE SENSITIVE MIRRO-BRITE made with "MYLAR"*

makes a dramatic difference on every product!



PEEL OFF BACKING—ADHERE

There's nothing quite like Mirro-Brite Mylar to give every product added eye-appeal at modest cost. It can be used in die-cut panels, decorative strips, grillwork and a countless number of other ways, limited only by your imagination!

Select your pattern from any of 26 embossed designs in six metallic colors with or without pressure sensitive adhesive backing. Available in continuous rolls, cut-to-size sheets, die-cuts, or in widths as narrow as one-half inch. Wide variety of laminations, gauges and special effects. Check with our design engineering department for assistance in selection and application to meet individual requirements. No cost or obligation.

Write for free brochure and price list

"PIONEERS IN METALIZED MATERIALS"

Part of Monsanto Ultron Vinyl Film

COATING PRODUCTS, INC.

DEPT. MM 101 WEST FOREST AVE. ENGLEWOOD, N.J.
NEW JERSEY: LOwell 8-0610 NEW YORK: Wisconsin 7-4435

*A DuPont Polyster film

ALSO MIRRO-BRITE ACETATE, POLYSTYRENE, BUTYRATE AND VINYL

For more information, turn to Reader Service card, circle No. 425

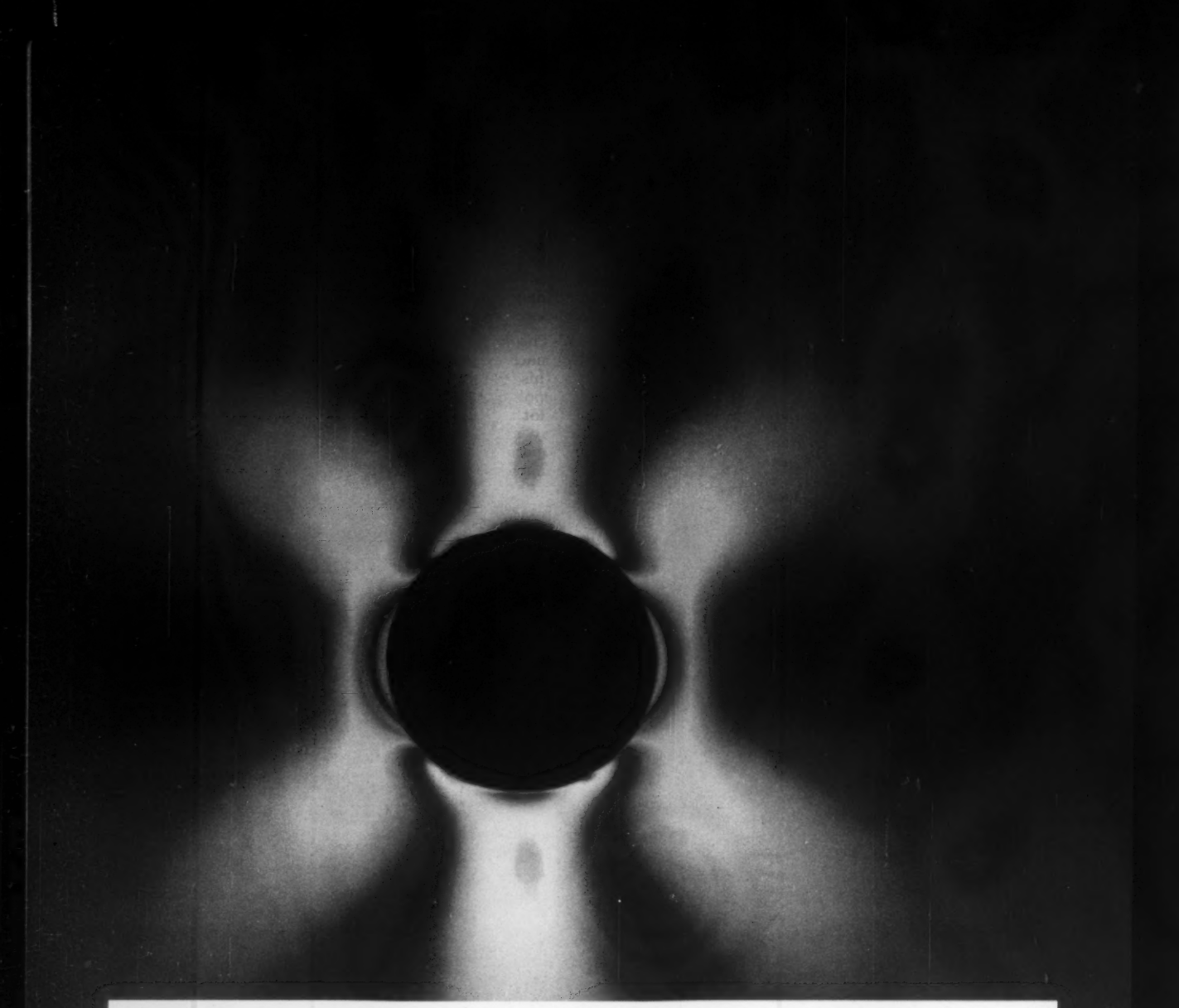


Photo-elastic stress patterns produced by models photographed with polarized light are one of the modern analytic tools available for ever-increasing perfection of Malleable iron castings.

For Greatest Strength Per Dollar... Use Malleable

To improve quality and cut costs, you'll find nothing better than Malleable iron castings. They provide more strength per dollar than any other metal, ferrous or non-ferrous! With Malleable you also get proven toughness, uniform quality and unsurpassed machinability.

See for yourself how much Malleable castings will improve your products and cut your costs. Send drawings or an outline of your requirements to a nearby Malleable castings producer who displays this symbol—

MEMBER
MALLEABLE
CASTINGS COUNCIL

For detailed information on "Strength Characteristics of Malleable Iron Castings", contact any of the progressive companies listed on the opposite page, or Malleable Castings Council, Union Commerce Building, Cleveland 14, Ohio.

"Value Analysis" Proves–

Malleable Castings Improve Quality, Reduce Costs

When "Value Analysis" is your task, consider these outstanding advantages of Malleable iron castings: more strength per dollar than any other metal, ferrous or non-ferrous; exceptional machinability; metal exactly and only where it is needed; job-proven toughness.

Wide Range of Desirable Properties Available in Malleable

Standard and pearlitic Malleable irons are available with strengths ranging from 50,000 p.s.i. to 120,000 p.s.i. tensile.

Note in this table the high ratio of yield strengths to tensile strengths — especially important to you because yield strength is generally the measure of useable strength.

TENSILE PROPERTIES—A.S.T.M. MINIMUM SPECIFICATIONS

Standard and Pearlitic Malleable Irons

Designation	Tensile Strength p. s. i.	Yield Strength p. s. i.	Yield as a Percent of Tensile
Standard			
35018	53,000	35,000	66
32510	50,000	32,500	65
Pearlitic			
45010	65,000	45,000	69
45007	68,000	45,000	66
48004	70,000	48,000	69
50007	75,000	50,000	67
53004	80,000	53,000	66
60003	80,000	60,000	75
80002	100,000	80,000	80

Strengths up to 135,000 p.s.i. tensile and 110,000 p.s.i. yield are produced commercially under individual producers' specifications.

Other Mechanical Properties

	Standard	Pearlitic
Modulus of Elasticity in Tension, p.s.i.	25,000,000	26,000,000 — 28,000,000
Ratio of Fatigue Strength to Tensile Strength	0.54	0.40 — 0.50
Shear Strength — % of Tensile Strength	80 — 90%	70 — 85%
Torsional Strength	Approximately equal to Tensile Strength	
Compressive Strength, p.s.i.	200,000	250,000

Switch to Malleable Saves 47% on Railroad Car Thrust Collar

One of countless examples of cost reduction obtained by changing from other materials or processes to Malleable castings is this thrust collar used on railroad maintenance cars. While the steel part formerly used performed satisfactorily, it cost 99¢ before machining.

The cost of the standard Malleable casting before machining is only 51.7¢ — a saving of 47.3¢! Added to this, four machining operations — drilling of bolt hole, spot facing for bolt head and nut, milling the sleeve slot and sawing the transverse slot — were eliminated by switching to a casting. All remaining machining operations are improved due to Malleable's exceptional machinability.

Former part before machining (99¢)

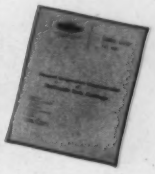
Malleable casting before machining (51.7¢)

Cost-Saving Engineering Assistance Available

The kind of engineering assistance that cut costs and improved product quality for these companies and thousands of others is available to you from any of the progressive producers of Malleable castings that are members of the Malleable Castings Council. Start increasing your product profitability right now — contact any of the companies listed below.

Free Information Folder

Your copy of an informative folder, *Data Unit 110—Malleable Castings in the Value Analysis Spotlight*, is available free from the Malleable Castings Council, Union Commerce Building, Cleveland 14, Ohio, or from any member company.



For Quality and Economy... Use MALLEABLE

For Service In Your Area Contact...

CONNECTICUT
Connecticut Mall. Castings Co., New Haven 6
Eastern Malleable Iron Co., Naugatuck
New Haven Malleable Iron Co., New Haven 4

DELAWARE
Eastern Malleable Iron Co., Wilmington 99

ILLINOIS
Central Fdry. Div., Gen. Motors, Danville
Chicago Malleable Castings Co., Chicago 43
Moline Malleable Iron Co., St. Charles
National Mall. and Steel Castings Co., Cicero 50
Peoria Malleable Castings Co., Peoria 1
Wagner Castings Company, Decatur

INDIANA
Albion Malleable Iron Company, Muncie Division, Muncie
Link-Belt Company, Indianapolis 6
National Mall. & Steel Castings Co., Indianapolis 22

IOWA
Iowa Malleable Iron Co., Fairfield

MASSACHUSETTS
Belcher Malleable Iron Co., Easton

MICHIGAN
Albion Malleable Iron Co., Albion
Auto Specialties Mfg. Co., Saint Joseph
Cadillac Malleable Iron Co., Cadillac
Central Fdry. Div., Gen. Motors, Saginaw

MINNESOTA
Northern Malleable Iron Co., St. Paul 6

MISSISSIPPI
Mississippi Malleable Iron Co., Meridian

NEW HAMPSHIRE
Laconia Malleable Iron Co., Laconia

NEW YORK
Acme Steel & Mall. Iron Works, Buffalo 7
Frazer & Jones Company Division Eastern Malleable Iron Co., Solvay
Oriskany Malleable Iron Co., Inc., Oriskany
Westmoreland Mall. Iron Co., Westmoreland

OHIO
American Malleable Castings Co., Marion
Central Fdry. Div., Gen. Motors, Defiance
Dayton Mall. Iron Co., Ironton Div., Ironton
Dayton Mall. Iron Co., Ohio Mall. Div., Columbus 16
Maumee Malleable Castings Co., Toledo 5
National Mall. and Steel Castings Co., Cleveland 6

PENNSYLVANIA
Buck Iron Company, Inc., Philadelphia 22
Erie Malleable Iron Co., Erie
Lancaster Malleable Castings Co., Lancaster
Lehigh Foundries Company, Easton
Meadville Malleable Iron Co., Meadville
Pennsylvania Malleable Iron Corp., Lancaster

TEXAS
Texas Foundries, Inc., Lufkin

WEST VIRGINIA
West Virginia Mall. Iron Co., Point Pleasant

WISCONSIN
Belle City Malleable Iron Co., Racine
Chain Belt Company, Milwaukee 1
Federal Malleable Company, Inc., West Allis 14
Kirsh Foundry Inc., Beaver Dam
Lakeside Malleable Castings Co., Racine
Milwaukee Malleable & Grey Iron Works, Milwaukee 48

For more information, turn to Reader Service card, circle No. 333

bend, stamp, cut,
and form away!
this handsome pre-finish
stays put

VINYL-ON-METAL is cooperative. Stamp it out. Punch it out. Even weld it! Form it the same ways you form unfinished sheets. The unique colors, textures and patterns of Vinyl-on-Metal sheeting or coils remain unaffected. The tough resilient surface stays—won't chip or peel in use. It protects against tearing or wrinkling—minimizes surface damage during fabrication and assembly. Vinyl-on-Metal is already widely and successfully used for furniture appliances, transportation interiors, building construction, and in many other fields. For a highly informative booklet, "Vinyl-on-Metal," write to Monsanto Chemical Company, Plastics Division, Room 753, Springfield 2, Mass.

Monsanto developed and today supplies Opalon® and Ultron® vinyls for superior finishes on steel, aluminum, and other metals, and on wood, paper and glass.

MONSANTO DEVELOPER IN **PLASTICS**

Monsanto®

For more information, circle No. 486

Looking for an Engineering Material that works two ways at once?

Check Urethane Elastomers

The big design engineering advantage of urethane elastomers is their combination of a high hardness range (from 60 Shore A durometer to 65-70 Shore D durometer) with high elasticity (elongation to 800%) which means a combination of working properties that gives you the structural strength of metals with the functional values of rubber.

Urethane elastomers are not merely another type of synthetic rubber; they are chemically-engineered materials with a completely new combination of properties. Properly designed urethane elastomer parts will outwear, out-perform other rubbers, plastics and many metals.

Elastomers made with Mobay's Multrathane® line of chemicals have passed severe OEM tests for abrasion, impact and ozone resistance, flexing strength and wear properties.

If you have not yet investigated urethane elastomers for your design engineering requirements, get the facts from Mobay. Ask for the Multrathane Engineer's Manual.

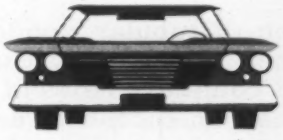
MOBAY CHEMICAL COMPANY
Dept. MD-13, Pittsburgh 5, Pa.

MOBAY
First in Urethane Chemistry

Mobay supplies Multrathane chemicals and technology for manufacturing urethane elastomers.

For more information, turn to Reader Service card, circle No. 461

Better products through better methods and steels

(or how zinc-coated steel cut 5 steps from auto lamp housing fabrication). When automotive head and tail lamp housings were drawn from cold rolled sheet steel and then zinc-plated or painted, as many as five or six handling and cleaning steps were required to make them corrosion-resistant. Now, fabricated from Weirkote continuous-process zinc-coated steel, the housings go directly from the press to the assembly line. Further processing is unnecessary because Weirkote can be worked to the limits of the steel itself without chipping or flaking its corrosion-resistant zinc surface. It's this superiority that caused the automobile industry to increase its consumption of zinc-coated steel more than 700% in five years; to use it in such varied applications as mufflers, window channels and the understructures of unitized bodies; to take  advantage of developments such as differentially zinc-coated steel that can be welded at top production-line speeds. A major supplier is Weirton Steel Company—producer of Weirkote continuous-process zinc-coated steel and many other fine steels that improve products, methods and profits throughout industry.

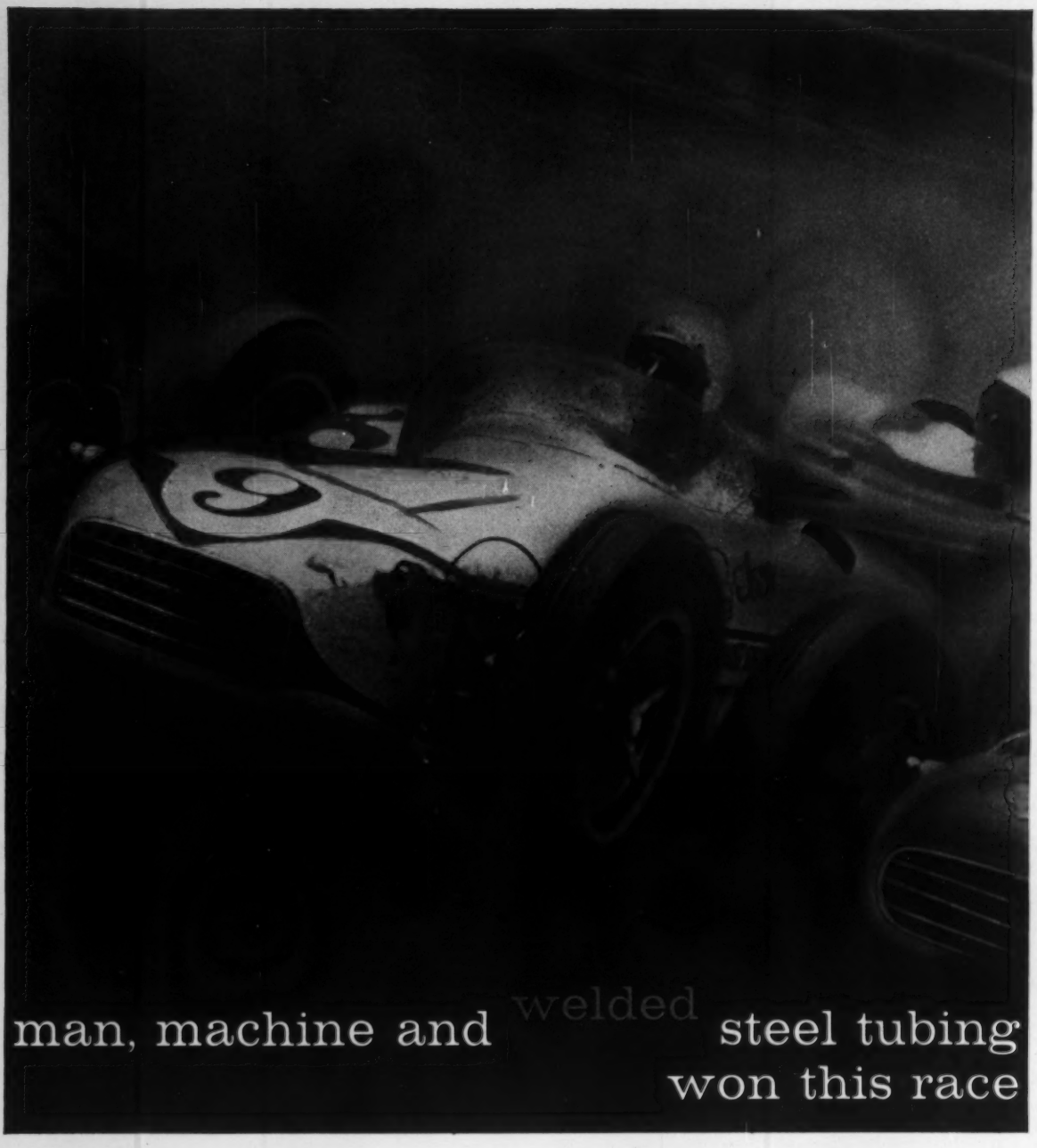
WEIRTON STEEL
Weirton, West Virginia

WEIRTON STEEL COMPANY

For more information, circle No. 379

Weirton Steel is a division of **NATIONAL STEEL CORPORATION**

Weirkote will also be available in 1961 from National's Midwest Steel division, Portage, Indiana.



man, machine and welded steel tubing won this race

You who are responsible for the purchase of tubular goods are assured highest quality and product reliability when you specify Standard. Over the past forty years Standard has supplied countless miles of electric weld boiler and heat exchanger, pressure and mechanical tubing and oil country tubing and casing to chemical plants, refineries and industries around the world. Let Standard specialists analyze your problem—quote on your job.

STANDARD

THE STANDARD TUBE COMPANY • 24400 PLYMOUTH ROAD, DETROIT 39, MICHIGAN

Welded stainless tubing and pipe • Welded carbon steel mechanical • Boiler and Heat Exchanger • Exclusive rigidized patterns • Special Shapes • Oil Well Tubing and Casing • Light Weight Pipe • Steel Tubing—Sizes: ¼" OD to 6" OD—.028 to .270 wall • Stainless Pipe and Tubing—Sizes ¼" OD to 4¾" OD—.020 to .187 wall.

For more information, turn to Reader Service card, circle No. 385

Escon® POLYPROPYLENE

for colorful, new non-slip rope...super-strong and it floats!

Another interesting use of versatile Escon: as rope, Escon filaments are easier on the hands than manila fibers. They don't have that greasy, slippery feeling noticeable in some other synthetic rope materials. Water absorption—a problem that plagues many cordage materials—is virtually eliminated with Escon filaments. Escon exhibits other desirable properties, too. Excellent wet strength—plus chemical and abrasion resistance—and full flexibility can be maintained at temperatures as low as minus 70°F. Brilliant color coding is also possible for easy identification. And Escon has shown no evidence of attack by fungus, rot and marine organisms. Escon as a filament can help produce better cordage as well as countless other products. Investigate Escon today!

For technical assistance or to order Escon, phone or write the Enjay office nearest you. (Home office) 15 West 51st Street, New York 19, N. Y. Other offices: Akron • Boston • Charlotte • Chicago • Detroit • Houston • Los Angeles • New Orleans • Tulsa • Toronto

EXCITING NEW PRODUCTS THROUGH PETRO-CHEMISTRY

ENJAY CHEMICAL COMPANY

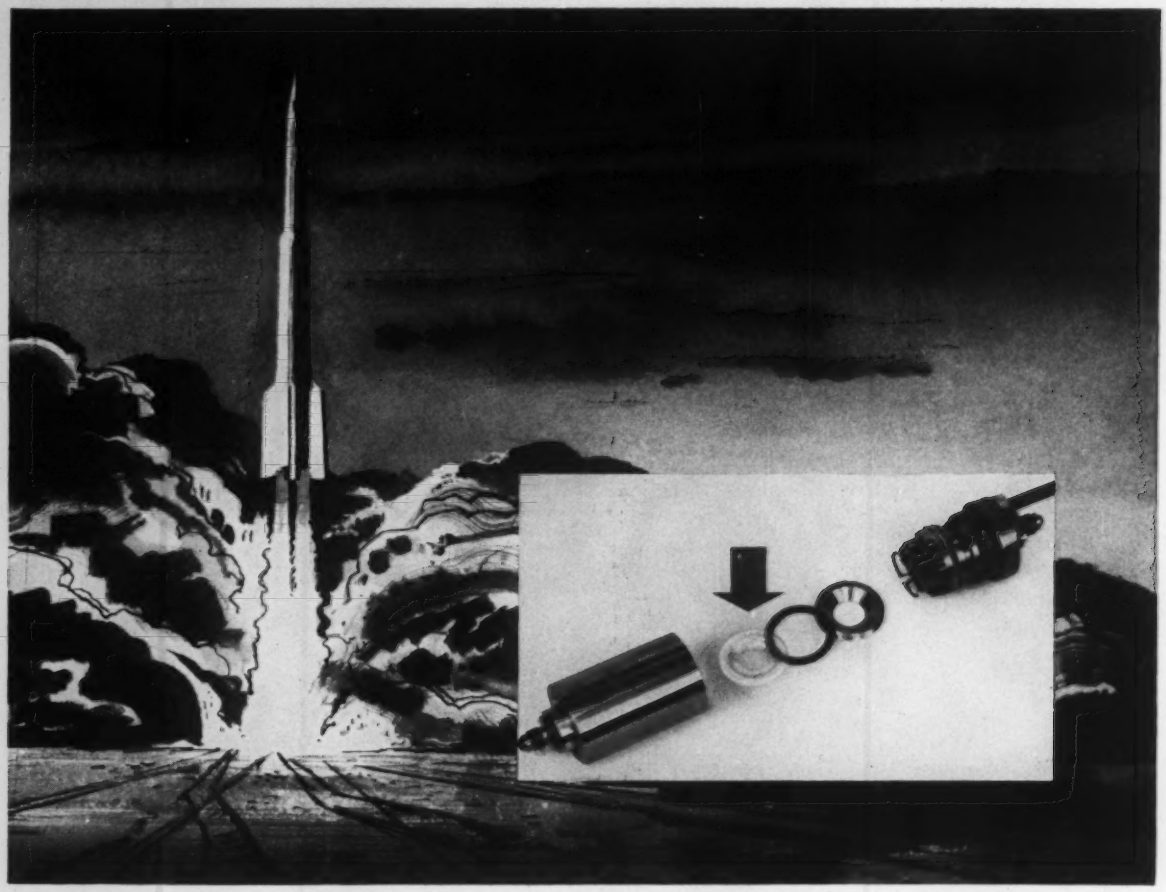
A DIVISION OF HUMBLE OIL & REFINING COMPANY

ENJAY PLASTICS

For more information, turn to Reader Service card, circle No. 397

3M COMPANY CHEMICALS

THE RAW MATERIALS OF PROGRESS



KEL-F® BRAND Plastic . . . proved reliability for tough pressure assignments

Shattering vibration . . . crushing acceleration . . . extreme temperature variance—these are factors Wiancko Engineering Company, Pasadena, California, is meeting in their differential pressure pickups for corrosive media with the help of KEL-F Brand Halofluorocarbon Polymers.

Used in rockets, these pickups measure the differential flow of highly corrosive media, such as red and white fuming nitric acid and oxygen. The pickup operates efficiently between 0°F. and 160°F., with a sensitivity change of less than 2% for a 100°F. change in temperature. The diaphragms (arrow above) are made of KEL-F Plastic and cast by Glaco Chemical Corp., a subsidiary of Ekco Products Co., Whittier, California. The damping fluid is KEL-F Brand Light Oil #1.

KEL-F Plastic was chosen because it is chemically inert, thermally stable, has high impact, tensile and compressive strength, and zero moisture absorption. This unique combination of features, plus others such as easy moldability, makes KEL-F Plastic ideal for many uses in aircraft, rockets and missiles. Included: O-rings, LOX lip seals, valve diaphragms, flow meters and fuel bladders.

KEL-F Brand Oils, Waxes and Greases, too, have remarkable properties. Their uses include: Compressor lubricants, damping fluids, hydraulic and pump fluids and liquid dielectrics.

For complete performance characteristics, write today specifying area of interest to: 3M Chemical Division, Dept. KAR-60, St. Paul 6, Minnesota.

"KEL-F" is a Reg. T.M. of 3M Co.

CHEMICAL DIVISION

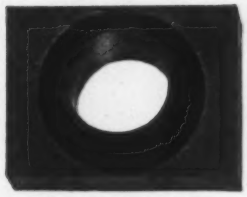
MINNESOTA MINING AND MANUFACTURING COMPANY

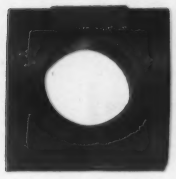
. . . WHERE RESEARCH IS THE KEY TO TOMORROW

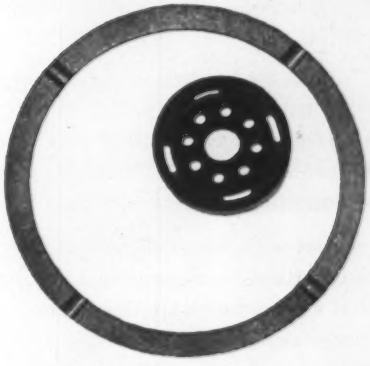
3M COMPANY

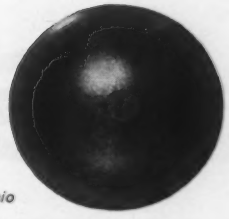
For more information, turn to Reader Service card, circle No. 362

ACCURACY, DURABILITY and ECONOMY are important characteristics of these sintered metal automotive suspension parts by Delco Moraine. Vital components such as these are typical results of close collaboration between Delco Moraine and its customers—an effective liaison that functions from idea through design and development to production. They also confirm Delco Moraine's equally important capabilities for making deliveries in quantity and on time!







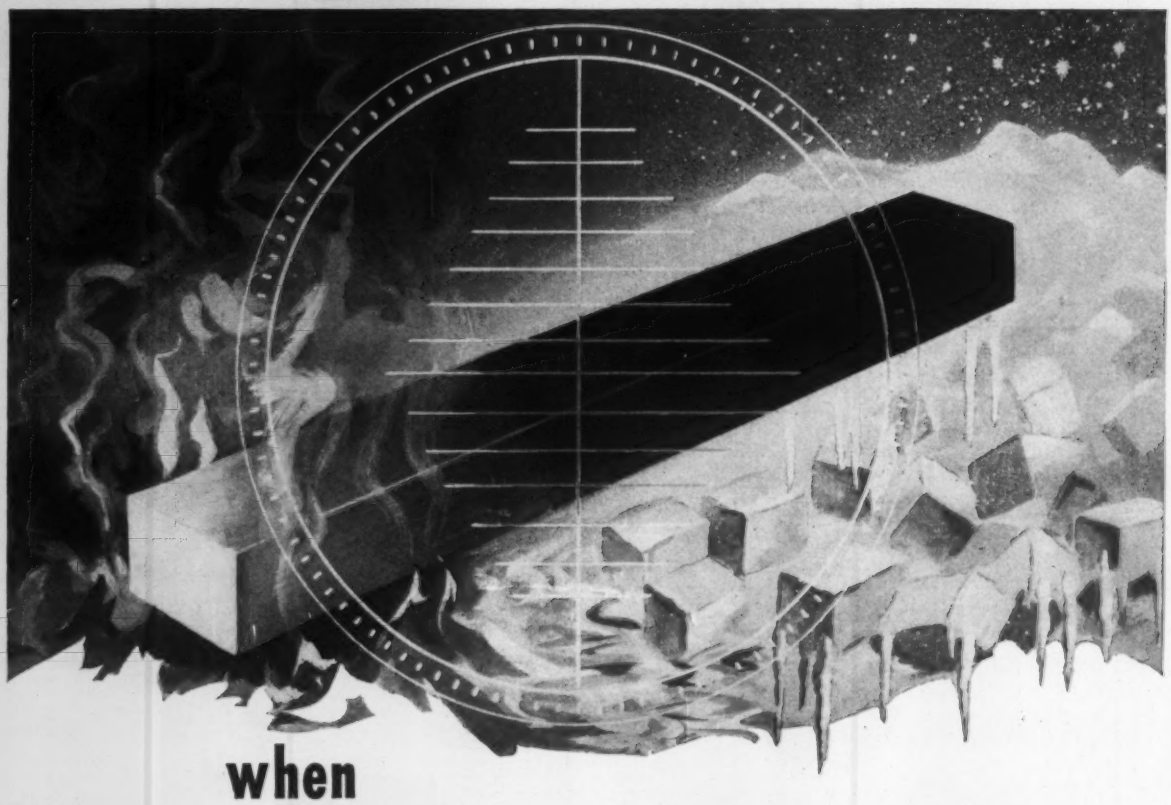


DELCO MORAINE

DEPENDABLY MADE parts for industrial progress • Division of General Motors, Dayton, Ohio

For more information, turn to Reader Service card, circle No. 400

V-R METALS...



when dimensional stability is needed!

Does the size of a metal part have to change as its temperature does . . . and if so how much?

The change in size under various conditions can be a very critical factor. A part that must function accurately at sea level might be required to maintain that accuracy on a flight to the moon when the ambient temperature is —240° F. Under these conditions a new metal may be indicated.

Producing metals with low coefficients of expansion under extreme temperatures for dimensional stability and control is part of V-R's everyday activities. If you need a part with this characteristic or possibly one that is highly corrosion resistant . . . or one that has long wearing qualities . . . or one that has to take an extremely fine surface finish . . . then contact V-R.

V-R VASCOLOY-RAMET

CREATING THE METALS THAT SHAPE THE FUTURE

A-781

848 MARKET STREET • WAUKEGAN, ILLINOIS

For more information, turn to Reader Service card, circle No. 345

Bridgeport Pre-painted Aluminum Strip is downright unique! Mirror smooth surfaces possess unusual hardness, are wear-resistant and virtually scuff-free during all forming operations. The special 2 coat finish utilizes a remarkable primer bonded tightly to the metallic surface. It strengthens the final coat, eliminates chipping, and insures maximum density and uniformity of color. Corrosion creep is simultaneously inhibited—even along metallic edges exposed in punching or shearing.

Bridgeport Pre-painted Aluminum Strip eliminates painting, insures a *superior* finish *without* finishing costs ...is proved by billions of feet now in worldwide use on Flexalum Venetian Blinds and exterior awnings. *Here is the ultimate in long lasting, exterior durability, resistance to chemical attack, sun, salt spray, wind and rain!* Now available in an almost unlimited range of sun-fast colors for a wide variety of applications.

For more beauty—for maximum formability use Bridgeport *Pre-painted* Aluminum Strip!

NOW AVAILABLE

NEW METALLICS AND WOOD GRAINS!

Here are the newest developments in Bridgeport Pre-painted Aluminum Strip designed to attract and please!

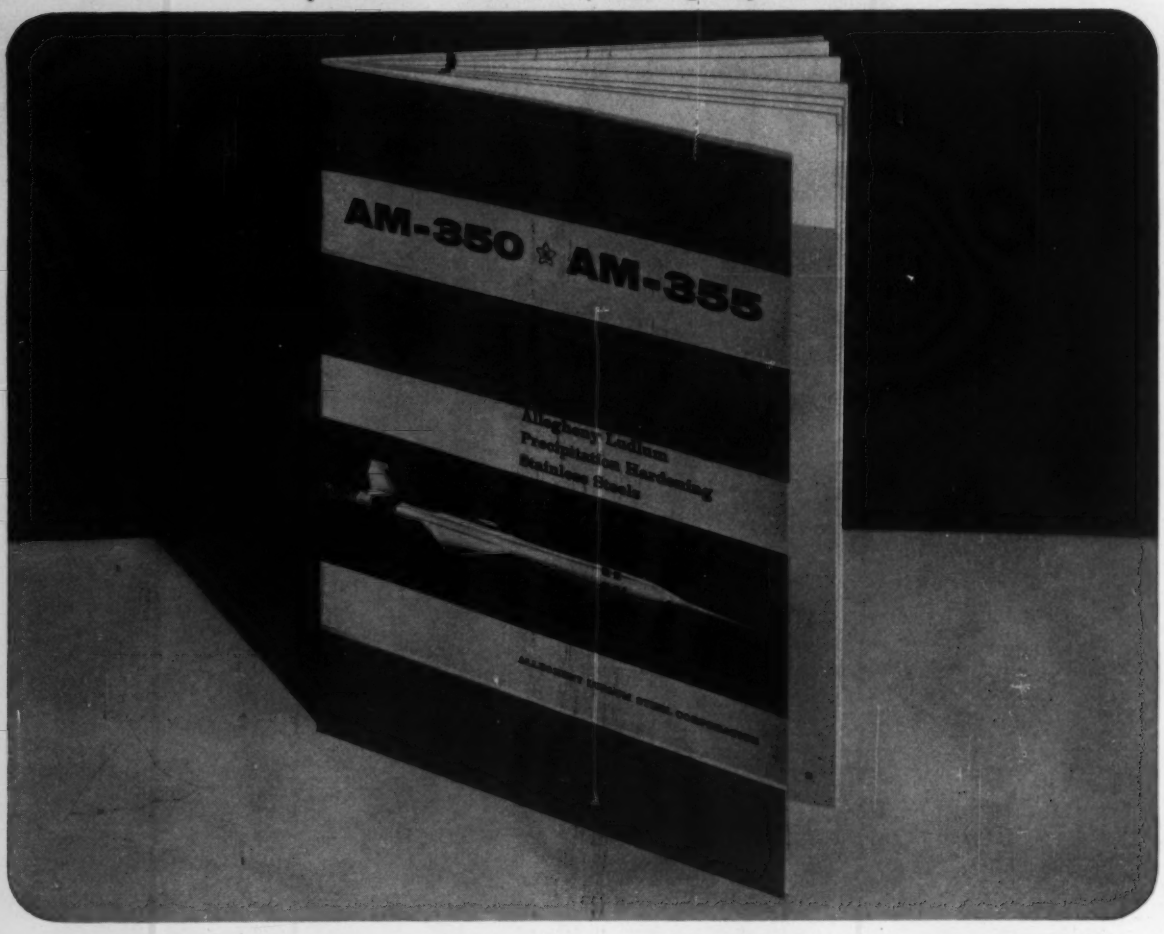
METALLICS in soft pastel colors, two finishes—glossy bright and satin sheen.

WOOD GRAINS with remarkable authenticity, lending new charm and attraction to indoor trim!

BRIDGEPORT BRASS COMPANY
Bridgeport 2, Connecticut • Sales Offices in Principal Cities
Specialists in Metals from Aluminum to Zirconium

For more information, turn to Reader Service card, circle No. 445

Experience**—the added alloy in **Allegheny Stainless



New booklet on A-L's precipitation-hardening stainless steels, AM-350 and AM-355

A tool for anyone interested in high strength-to-weight metals

In this technical booklet, you get the facts on Allegheny Ludlum's precipitation hardening stainless steels, AM-350 and AM-355, metals developed for space age requirements.

AM-350 and AM-355 combine these unusual qualities. They are easy to fabricate. Have high strength-to-weight ratios at room and elevated temperatures combined with excellent resistance to corrosion.

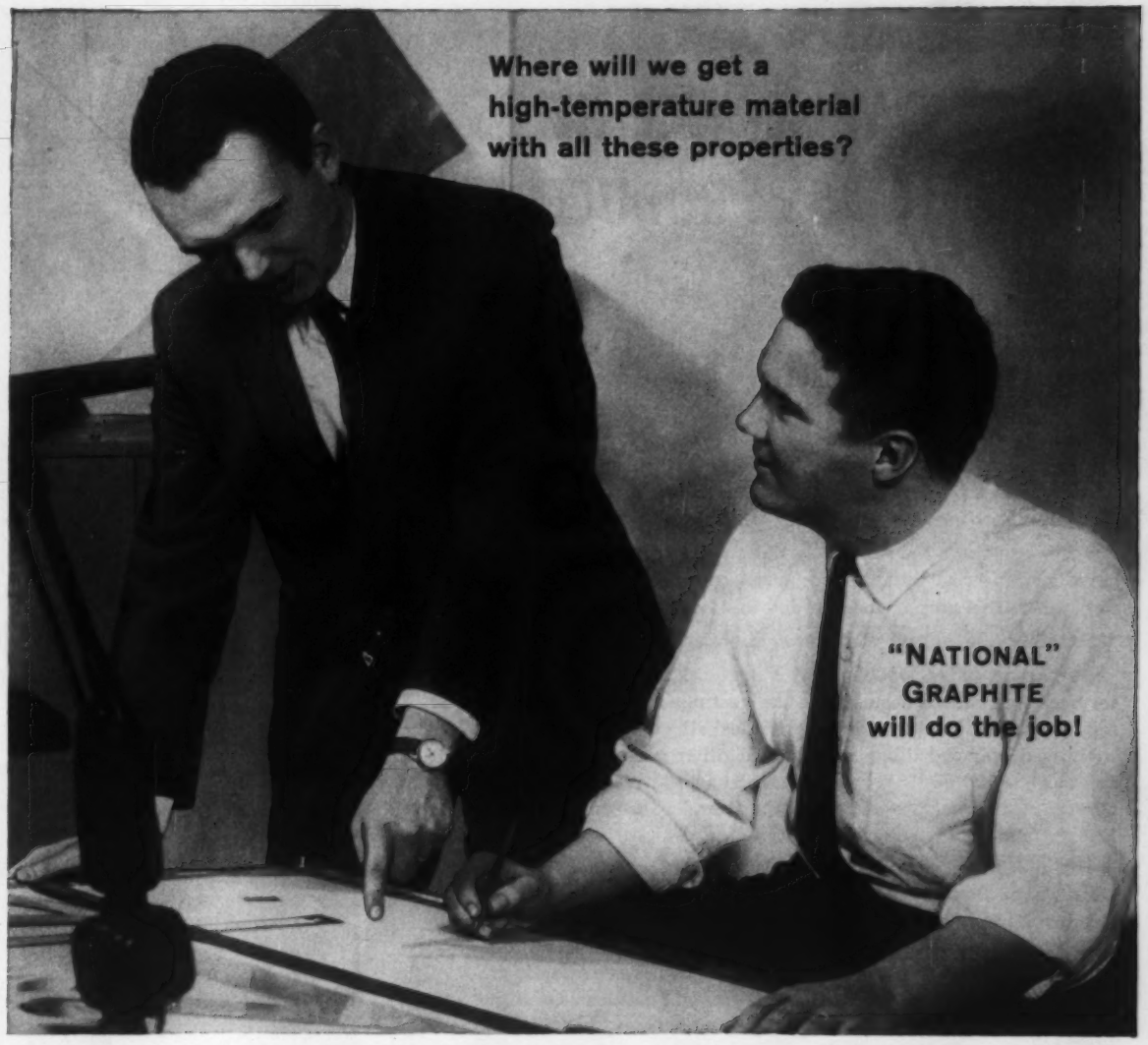
The physical and mechanical properties of the two metals are described in 33 charts and tables. Included are heat-treatment and fabrication data, eight photomicrographs and a section on corrosion resistance with representative values in selected environments.

It's jam-packed with data. For your free copy, see your A-L representative or write *Allegheny Ludlum Steel Corporation, Oliver Building, Pittsburgh 22, Pa. Address Dept. MI-6.*

ALLEGHENY LUDLUM

EVERY FORM OF STAINLESS . . . EVERY HELP IN USING IT

For more information, turn to Reader Service card, circle No. 471



MR. ENGINEER: HAVE YOU THOUGHT OF NATIONAL GRAPHITE?

When design problems involve high temperatures, you can save time and money by including "National" graphite in the initial "specs." Don't wait until all other materials fail . . . start with this proved high temperature material.

Why? Because of some of these unique properties offered by "National" graphite: exceptional resistance to thermal shock . . . high heat transfer . . . low thermal expansion (1/6 that of steel) . . . no loss (actually increases) in strength to 4500 degrees F . . . no reaction with most molten metals and slags . . . a good electrical conductor, yet low enough to be used as a resistor . . . easy to machine to intricate shapes and close tolerances. It is available in a wide range of grades and sizes — and is economical in price.

Apply the unique property combinations of "National" graphite to your high temperature design problems. Today, more and more design engineers are finding this material does the job efficiently at low overall costs.

For details, write National Carbon Company, Division of Union Carbide Corporation, 270 Park Avenue, New York 17, N. Y. In Canada: Union Carbide Canada Limited, Toronto.

"National" and "Union Carbide" are registered trade-marks for products of

NATIONAL CARBON COMPANY

UNION CARBIDE

For more information, turn to Reader Service card, circle No. 411

HOW DOEHLER-JARVIS' DAY-TO-DAY SERVICE HELPS MELNOR MASS PRODUCE HIGH QUALITY LAWN EQUIPMENT

Melnor Industries, Inc., is the leader in garden sprinklers and related hose hardware . . . items designed to high mechanical standards, modernly styled, priced for volume sale.

From the start, most parts of most items in the Melnor line have been die cast by Doehler-Jarvis . . . for reasons that Melnor sums up in the simple phrase, "day-to-day service."

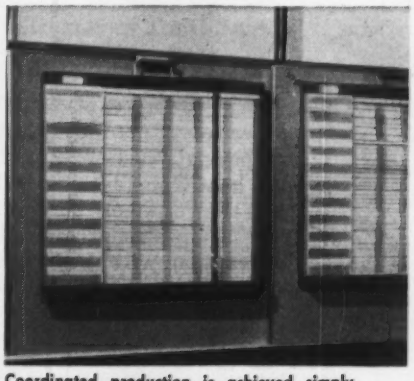
But this is a phrase that needs illumination, needs specifics.

Just what does Doehler-Jarvis include in this "day-to-day service" that means so much to die castings customers? As you might expect, Doehler-Jarvis provides all customary services, such as tapping, drilling, milling and other pre-assembly work. Doehler-Jarvis provides important extras, too . . . extensive assistance in parts design, for example, and complete finishing facilities. Even sub-assembly may be negotiated, if desired.

But more important than these is a sort of informal "partnership for production" . . . where key people in D-J keep in daily touch with their opposite numbers . . . with D-J's sales engineer coordinating all along the line. Through this mutual understanding and interchange of process knowledge, design is continually improved, costs continually reduced. Often difficulties are anticipated and entirely avoided by the close *personal* contact that exists at all working levels with Doehler-Jarvis customers.

Pictures at right show some of the points of contact . . . show some of the Doehler-Jarvis facilities that make this unique working relationship pay off for Melnor . . . as a comparable relationship might for you.

Close liaison during die design does much to keep Melnor's costs down. At this stage slight modifications in die or part often eliminate one or more operations. To attain this flexibility, D-J designs and makes its own dies.



Coordinated production is achieved simply. It's done by a daily telephone call that establishes Melnor's needs for the next two days.

Doehler-Jarvis

Division of
NATIONAL LEAD COMPANY
General Offices: Toledo 1, Ohio
Plants at:
Toledo
Grand Rapids 2, Mich.
Pottstown, Pa.
Batavia, N. Y.

In Canada: **Barber Die Casting Co. Limited**
Hamilton, Ontario

In Brazil: **Industrias Doehler do Brasil, S.A.**
Sao Bernardo do Campo, Sao Paulo

Idea exchange starts early! You are looking in on a tough-minded, sharp-pencil work session. At this one, Melnor and Doehler-Jarvis decision makers are setting basic production requirements for a new sprinkler model. During production informal meetings between individual members of this group will keep production moving smoothly.

Joint meetings establish production cost limits. Then D-J automates to bring costs within requirements. Ordinarily, automatic tooling is developed and made in Doehler-Jarvis' own shops... as was this 12-station, indexing tool.

Two heads have proved better than one in giving Melnor products durable low-cost finishes, so specialists from both companies confer frequently. D-J both plates and paints. Modern inspection guards finish quality.

Mutual considerations bring packing innovation. Until recently, D-J shipments went to Melnor in throw-away packages. To save money and time at both plants, D-J engineers designed the money-saving re-use container above.

Before closing, D-J has its trucks loaded for the next day's delivery and has started preparing shipments for the succeeding day.

Plant-to-plant delivery is direct and fast. Shipments to Melnor go in one or more of Doehler-Jarvis' own tractor-trailors, arriving early in the morning. Coordination is so close that neither plant is called upon to carry high parts inventories.

For more information, turn to Reader Service card, circle No. 381

This won't stop corrosion—

but versatile-flexible

TYGON® WILL!

Simply crossing the fingers doesn't help much when it comes to corrosion control. But a sure-fire method—and much more economical in the long run—is to specify Tygon if corrosion is a problem in any product you make. Available in a variety of convenient forms and job-specified formulations, Tygon offers superior resistance to a wide range of acids, alkalies, salts, alcohols, oils and solvents.

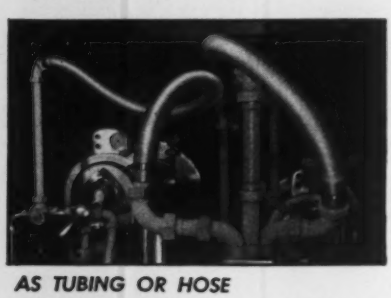
CHECK THE WAYS TYGON CAN IMPROVE VALUE AND PERFORMANCE OF YOUR PRODUCT

AS A COATING

Easily applied by brush, spray, dip or roller-coat, Tygon forms a fast-cure, tough, impermeable plastic barrier that seals out corrosive fumes and acids. Gives equipment longer lasting protection against chemical attack and extreme moisture.

AS LININGS

Tygon Sheeting offers heavy-duty protection against corrosive solutions in storage and processing tanks of all shapes and sizes. Easier to install, handles many of the tough jobs rubber and other linings cannot do.

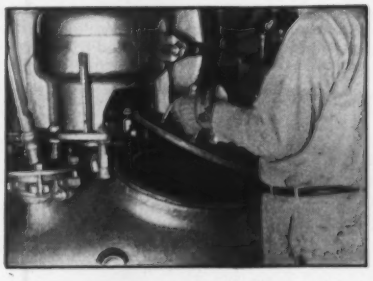


AS TUBING OR HOSE

Flexible, glass-clear Tygon Tubing is ideal for piping flavor-sensitive liquid foods or corrosive chemicals. Non-toxic, non-contaminating, sterilizable. Tough, durable, abrasion-resistant for long service life. Available 1/16" to 4" I.D.

AS GASKETING

Tough, resilient Tygon Gasketing assures tight, durable, leak-proof sealing. Its excellent chemical resistance eliminates costly corrosion "trouble spots" where other materials fail. Cut from sheet, tubing, solid cord, or molded to your specifications.



Write for detailed Tygon Portfolio today—or ask our engineering staff to recommend the proper Tygon formulation for your application.

445-F

PLASTICS AND SYNTHETICS DIVISION

U. S. STONEWARE

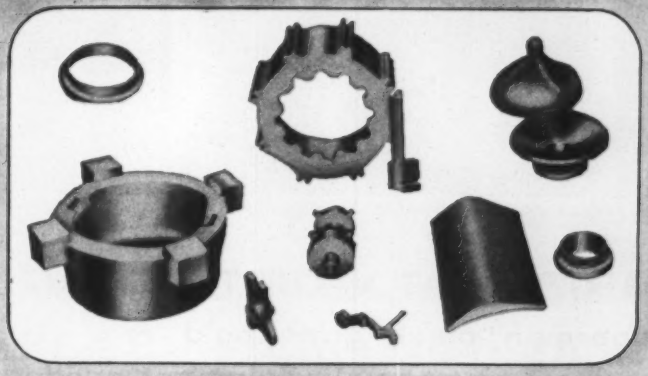
AKRON 9, OHIO

For more information, turn to Reader Service card, circle No. 455

you will be interested in ZEMO®

...an entirely new and exclusive development for making precise high alloy castings in a way that provides for closer tolerances in high quality steel.

Developed by USMAC...the Steel Castings Division of U.S. Magnet & Alloy Corporation...ZEMO high integrity steel castings are actually lower in overall cost—yet, of the highest quality. ZEMO castings produced in USMAC's modern, high efficiency plant are delivered in a condition which precludes a number of expensive finishing operations. Thus...because there is considerably less finishing and machining required—you save both time and money.



USMAC SERVES ALL INDUSTRIES...from food process machinery to rockets and missiles. A partial list of the many types of industries includes: Pumps and Compressors ■ Gas and Steam Turbines ■ Chemical Equipment ■ General Machinery ■ Dairy Product Machinery ■ Glass Pressing ■ Aircraft Industries such as—Airframes; Fuel Systems; Engines; Landing Gear; Brakes; Controls; Armament and Aircraft Ground Support.

IF YOU HAVE A PROBLEM...design, production or cost reduction...CONTACT THE MAN FROM USMAC. USMAC's staff of highly experienced foundry engineers will study your problem without any obligation. Address inquiries to Department 6-01. For additional information please request Brochure 01 on Company letterhead.

USMAC STEEL CASTINGS DIVISION
U. S. MAGNET & ALLOY CORPORATION
266 Glenwood Avenue · Bloomfield, New Jersey

For more information, turn to Reader Service card, circle No. 368

TRAPPED BY A GRIP THAT WON'T LET GO!

See how Tinnerman "pinch-grips" hold front-mounting attachments; no special equipment needed

Typical of Tinnerman *new approaches to old problems* are "pinch-grip" SPEED CLIPS—permitting front-of-panel applications in a second's time. SPEED CLIPS are simply inserted into mounting holes and a plier's pinch gives permanent retention.

SPEED CLIPS can increase production rates, eliminate rejects, cut assembly costs as much as 50%. Many different features may be incorporated in the SPEED CLIP design to fasten cables, wire harness, rubber feet, mouldings, and for scores of other assemblies.

You may have a fastening problem that can be solved—or a product which can be improved—by this SPEED CLIP principle. Your Tinnerman specialist (see the Yellow Pages) can furnish samples and help you in many ways. Or write:

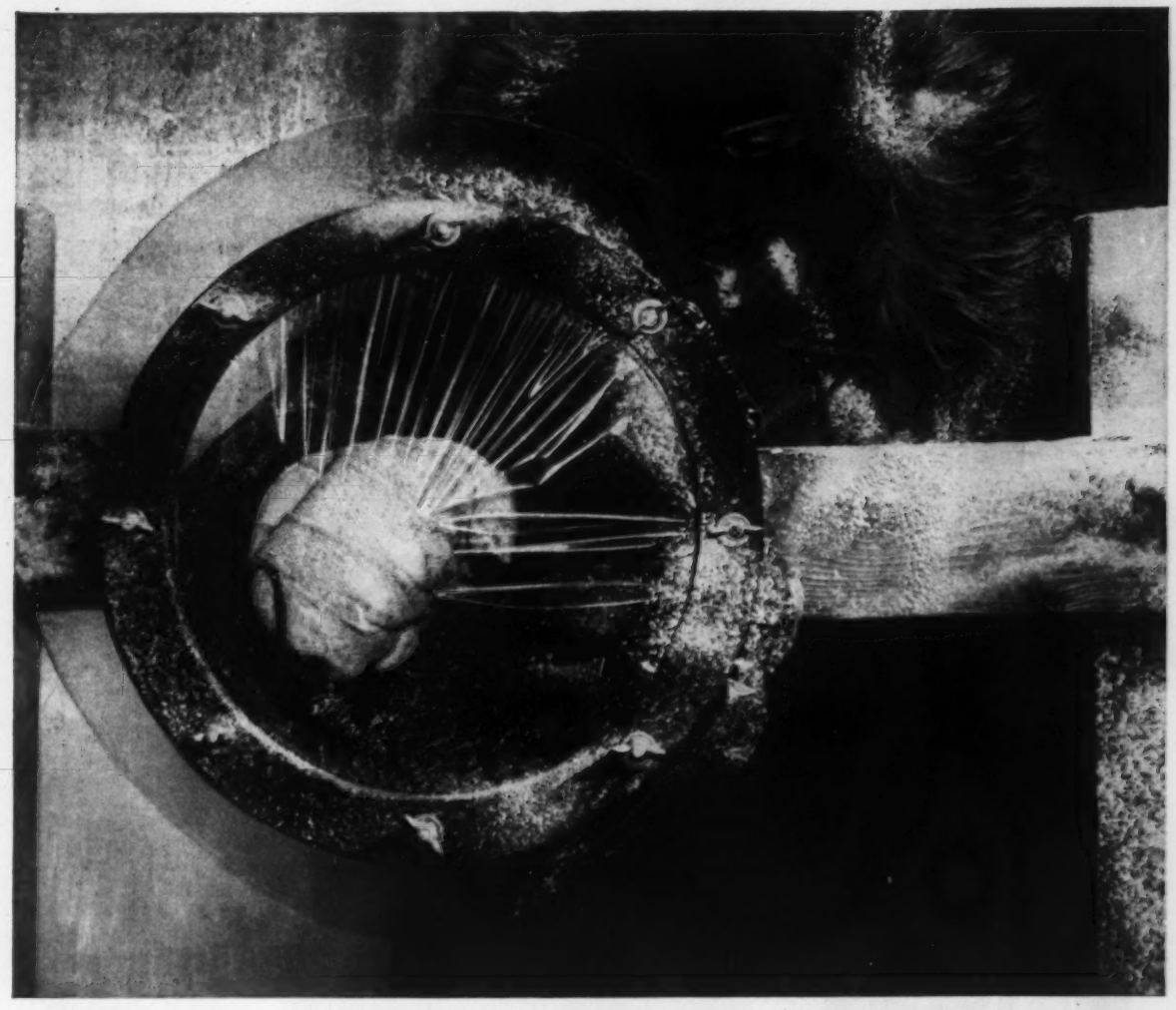
TINNERMAN PRODUCTS, INC.
Dept. 12 • P. O. Box 6688 • Cleveland 1, Ohio

TINNERMAN
Speed Nuts®

FASTEST THING IN FASTENINGS®

CANADA: Dominion Fasteners Ltd., Hamilton, Ontario. GREAT BRITAIN: Simmonds Aerocessories Ltd., Treforest, Wales. FRANCE: Simmonds S. A., 3 rue Salomon de Rothschild, Suresnes (Seine). GERMANY: Hecano-Bondy GmbH, Heidelberg.

For more information, turn to Reader Service card, circle No. 390



MYLAR® retains its high strength at -60°C.

Can the unique combination of properties found in "Mylar" help you solve your design problems?

Weatherable "Mylar" Type W resists ultraviolet light. This new film, with all the outstanding properties of regular "Mylar", will withstand long exposure to the sun's ultraviolet light. The film offers new design opportunities for outdoor applications.

"Mylar"* polyester film is a tough, flexible engineering material. In addition to its resistance to temperature extremes (-60° to 150°C.), "Mylar" has an average tensile strength of 20,000 psi, a dielectric strength of 4,000 volts per mil for 1 mil film, plus excellent resistance to most chemicals and moisture.

On an area basis, tough, thin "Mylar" often *costs less* than heavier, conventional materials. "Mylar" can be laminated, embossed and metalized, punched or coated. The film won't embrittle with age. "Mylar" is available in roll or sheet form in a wide range of gauges.

Find out how the *combination of properties* in "Mylar" can help you solve knotty design problems, improve product performance or cut cost. Write today for our new booklet containing detailed information on properties and applications. E. I. du Pont de Nemours & Co. (Inc.), Film Department, Room MM-9, Wilmington 98, Delaware.

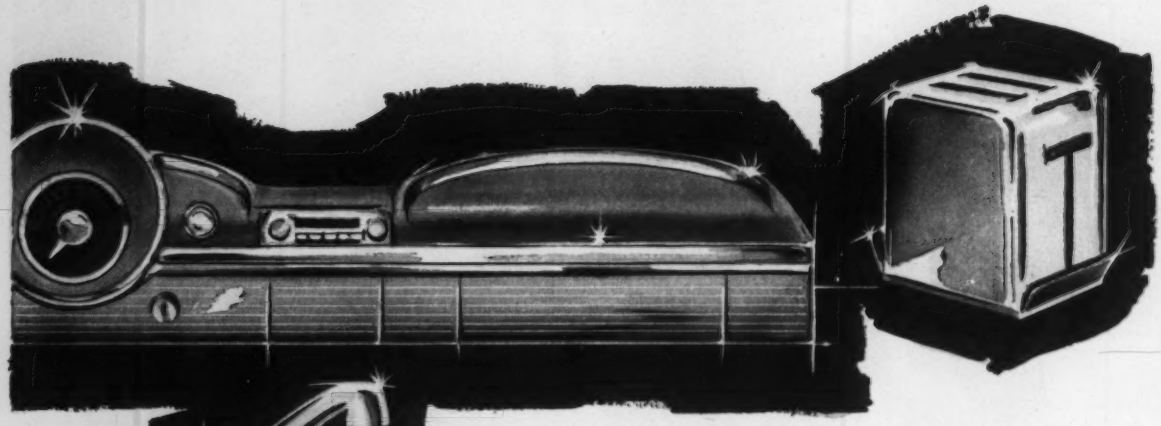
*"Mylar" is Du Pont's registered trademark for its brand of polyester film.

DU PONT
REG. U.S. PAT. OFF.

BETTER THINGS FOR BETTER LIVING
...THROUGH CHEMISTRY

DU PONT
MYLAR
POLYESTER FILM

For more information, turn to Reader Service card, circle No. 451



No Bright Nickel ever offered more

THE UNIVERSALLY APPROVED

HARSHAW NUBRITE

BRIGHT NICKEL PROCESS

Only Harshaw Nubrite meets all of the following qualifications:

1. *Most experienced* bright nickel process. The Harshaw Nubrite Bright Nickel process has given outstanding results to platers for many years.

2. Accepted as superior—*throughout the world.* Harshaw service is available to users throughout the world with distribution or manufacturing facilities in England, Holland, Australia, and Canada.

3. Operates *successfully* with either *air or mechanical agitation.* Recent improvements permit operation with *either* air or mechanical agitation, depending on *your requirements.*

4. Fast brightness—without sacrificing leveling, ductility, or *outstanding economy.*

5. Addition agents (*all liquid*) stocked throughout the world. Ease of operation is aided by the use of all liquid addition agents in easy to handle containers.

Join the growing number of satisfied users by contacting your nearest Harshaw Branch or write for informative free booklet: Harshaw Nickel Plating Processes.

HARSHAW

THE HARSHAW CHEMICAL COMPANY

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Philadelphia 48, Pa. • Pittsburgh 22, Pa.

Plating Processes also available through the following Foreign Distributors or Manufacturers:

Harshaw Chemicals Ltd., London, England
Armalite Co. Ltd., Toronto, Canada
L. Van Der Hoorn, Utrecht, Holland
Robert Bryce & Co. Ltd., Melbourne, Australia

And many Agents throughout the world

For more information, turn to Reader Service card, circle No. 388

Tool Steel Topics

BETHLEHEM STEEL COMPANY, BETHLEHEM, PA.

Export Distributor: Bethlehem Steel Export Corporation

Another report on Lehigh H tool steel—
"good machinability . . . very low distortion"

7-STAGE DIE FORMS AUTOMOTIVE DECK HINGE PART

This 7-position progressive die of Bethlehem Lehigh H tool steel was made recently by Hillside Tool & Die Company, Roseville, Michigan, for the production of an automotive deck hinge part, from 13-gage sheet steel. The die, made from Lehigh H supplied by our local distributor, Peninsular Steel Co., Detroit, was hardened to Rockwell C 60. It was used in a 400-ton press.

When asked about the performance of the tool steel, a Hillside engineer reported, "We like Lehigh H in jobs of this type because of its good machinability, and its very low distortion during heat-treatment. The die was placed in service with hardly any stoning necessary."

Bethlehem Lehigh H (AISI D-2) is our easy-machining, high-carbon, high-chrome grade of air-hardening tool steel. It has outstanding wear-resistance, due to its excellent carbide distribution.

Your Bethlehem tool steel distributor can give you full details on Lehigh H . . . and he has many sizes in stock.

BETHLEHEM TOOL STEEL ENGINEER SAYS:

Here's how to shrink-fit tool inserts

Shrink-fitting of tool steel inserts, commonly used in improving the service life of tools, is most applicable to rings and cylinders used in heading and drawing operations, where the tools can be shrink-fitted into large retaining rings. The shrink-fit sets up radial compressive stress in the tool. This serves to oppose radial tensile stress set up in service, thereby improving the performance over solid tools which are not pre-stressed.

Here's how to do it:

1. The retainer should have adequate diameter and strength to provide the stresses required on the tool insert. Generally, an alloy steel capable of hardening to 300-400 BHN is used. Shock-resisting tool steels, heat-treated to Rockwell C 48-52, are recommended for heavy-duty applications. The OD of the retainer should be at least twice, and preferably three times, the ID.

2. Allow for a shrink-fit of .003/.004 in. per in. Thus the OD of the insert is .003/.004 in. per in. larger than the ID of the retainer into which it is to fit. These dimensions must be maintained to obtain the benefits of shrink-fitting.

3. It is important that the OD of the insert and the ID of the retainer have a smooth finish, preferably produced by grinding.

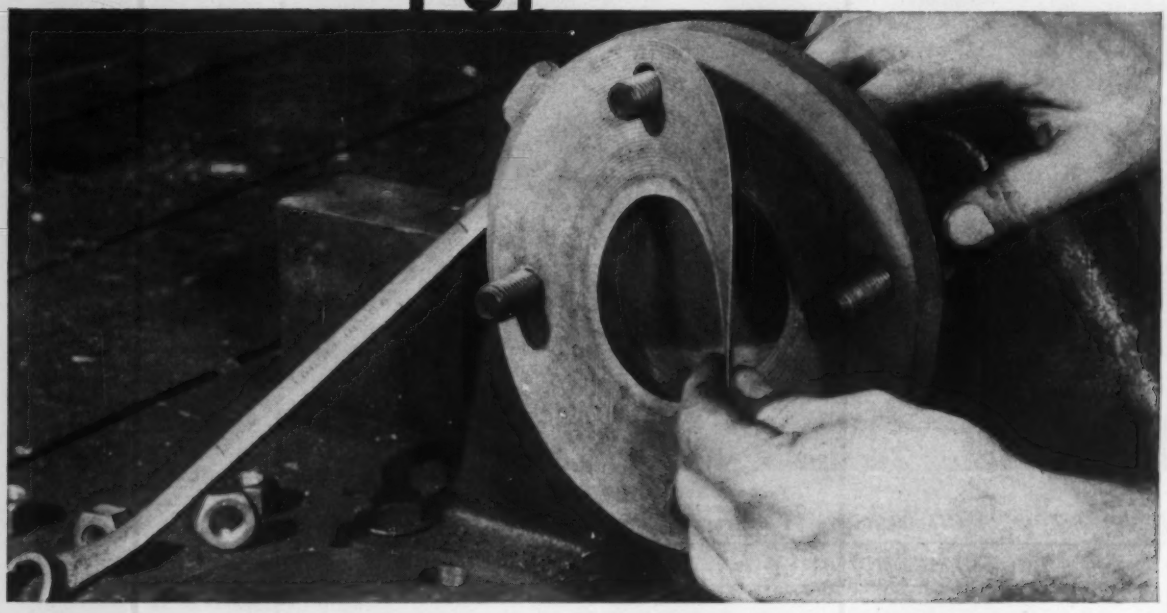
4. Heat the retainer to a temperature sufficient to cause the expansion required in assembling the insert. Do not exceed the tempering temperature used in heat-treating the retainer. If necessary, the insert may be sub-zero cooled, to help provide the proper clearance for assembly.

5. After assembly of the parts, the assembly should be cooled rapidly. This will prevent over-tempering of the insert by heat transferred from the retainer.

For more information, turn to Reader Service card, circle No. 321

AFTER HIGH PSI

. . . easy release without messy coating
. . . no delamination



Furnished in rolls, coils, sheets or precision fabricated.

Thickness: .007" through .031"

Thickness Tolerance: Plus or minus 10%

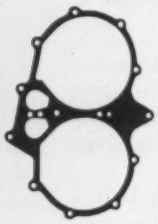
Compressibility Range: 6-15% @ 1000 psi. load

Compression Set: 15% Maximum

Recovery: 50% Minimum after 1000 psi. load

Tensile Strength:
Longitudinal — 10,000 psi.
Transverse — 4,000 psi. Minimum

For More Data, write Spaulding



SPAULDING 44 *GASKET MATERIAL...*

gives the engineer new freedom to cope with critical characteristics of design through its uniform compressibility and recovery, high tensile strength, cleanliness and resistance to fuels and oils.

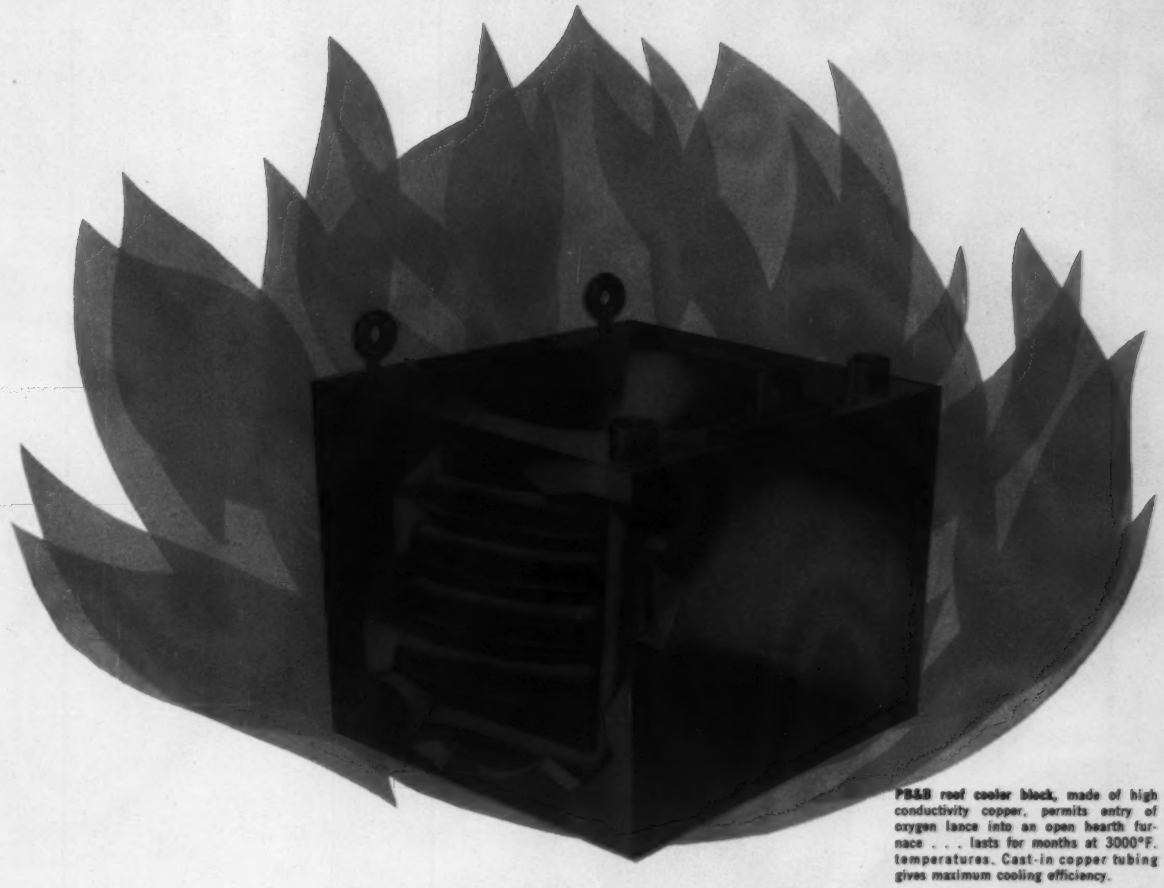
Spaulding 44 is typical of Spaulding's countless applications for industry.

Progress Reports on other Spaulding materials are available on request.

SPAULDING FIBRE COMPANY, INC.

360 WHEELER STREET • TONAWANDA, NEW YORK

For more information, turn to Reader Service card, circle No. 337



PB&B roof cooler block, made of high conductivity copper, permits entry of oxygen lance into an open hearth furnace . . . lasts for months at 3000°F. temperatures. Cast-in copper tubing gives maximum cooling efficiency.

HIGH CONDUCTIVITY COPPER

...versatile high temperature material

At temperatures where most metals soften or melt, high conductivity copper often can outlast other materials. But—it takes special techniques to make copper live in extreme heat. We have a wealth of experience in this field; here's what we can do for you when you need cast or forged copper components for high temperature duty.

MAXIMUM COOLING IS ESSENTIAL. We have developed methods for casting copper cooling tubing in place in high conductivity copper, to obtain maximum heat transfer.

HIGHEST CONDUCTIVITY COPPER. All copper is not alike: most copper castings have a conductivity of less than 70%, sometimes going as low as 25%, and do not give efficient heat transfer. For castings, we use virgin electrolytic copper guaranteed at least 90% IACS conductivity. Our forgings are made of OFHC* copper, and are guaranteed at least 98% IACS conductivity. Where high strength as well as conductivity is required, we supply alloys of copper . . . chrome, beryllium, zirconium . . . in castings and forgings.

PROCESSING AND TESTING. Our castings and forgings are processed using special techniques developed by us to assure highest possible conductivity. Every piece is checked on a magnatester and its conductivity is individually certified.

We will welcome the opportunity to discuss how high conductivity alloys . . . produced the PB&B way . . . can solve your high temperature problems. Call or write for a consultation.

*Registered trademark—American Metal Climax, Inc.

HIGH NICKEL ALLOY CASTINGS AND FORGINGS

Call on us for high quality, prompt delivery on castings and forgings of high nickel alloys for extreme temperature service:

Monel**, nickel, cupro-nickel, K Monel**, Inconel**, nuclear quality Inconel.

Our facilities and forty years of experience in non-ferrous production are ready to serve you.

**Registered trademark—International Nickel Comany

PHILADELPHIA BRONZE & BRASS CORP.

22nd and Master Streets, Philadelphia 21, Pa.

a subsidiary of

P. R. MALLORY & CO. INC.

MALLORY

For more information, turn to Reader Service card, circle No. 463

Joe Foster, President, suggests the range of Foster Grant's engineering services.

"Design molds for a resin customer? Sure, and we'll production-prove them for you, too," says Joe Foster.

Not that designing molds is our business.

Basically, we're suppliers of polystyrene, impact polystyrene and Nylon 6 resins, and we're also the world's largest manufacturer of sunglasses. But quite often a customer takes us up on our standing offer — of technical assistance in any area, from materials and machines to packaging and marketing.

Take last Fall, for instance. One of our customers was in Leominster, so we invited him to drop over and see our facilities. He molds combs, and one glance convinced him that some of our ideas might make his operation more productive.

We then offered to furnish him an improved mold, designed for his needs and tested by us **on his own machines.** Result — he now gets 16 combs per "shot" instead of 8, semi-automatic instead of hand de-gating, and a 26% shorter cycling time. No more grinding or buffing, either... for a yearly saving of more than $100,000!

Why not see if our engineering services can help **you.** Call or write us today. Foster Grant Co., Inc., Leominster, Mass., KEystone 4-6511.

For more information, turn to Reader Service card, circle No. 470

FG

FOSTER GRANT

Your Partner in Plastics Progress

Plants in Leominster, Mass., Manchester, N. H., Baton Rouge, La.
Branch Offices and Warehouses in principal cities

The seams don't show

Beautiful fit, beautiful look, beautiful soft drink dispenser. Beautiful job of close tolerance molding by General American. Working from wooden patterns, General American engineers designed six individual moldings. The shrinkage of each separate part was calculated to the thousandths of an inch. General American made the tools with the same precision.

Result—when this soft drink dispenser is assembled the seams are practically unnoticeable. In addition, the selection of the proper plastic, combined with General American's skill in molding, provides a product with very good luster, high impact properties, excellent stain resistance—and a reasonable price tag.

If you have a part or product that could or should be made of plastics, consult General American. In plastics, *it pays to plan with General American.*

in this 6-piece soft drink dispenser

GENERAL AMERICAN TRANSPORTATION CORPORATION

135 South LaSalle ... Chicago ... Illinois

... principal cities

PLASTICS DIVISION GENERAL AMERICAN TRADE MARK

For more information, turn to Reader Service card, circle No. 416

Combining high strength, corrosion resistance and toughness:

HERCULOY*
SILICON BRONZE CASTING ALLOY

Herculoy is an economical replacement for the costlier high tin content bronzes for many applications. It finishes to a rich golden color. Its strength is comparable to low and medium carbon steels. Its corrosion resistance is comparable to that of pure copper. Herculoy, with extremely low electrical conductivity, is also non-magnetic, easily worked hot, castable without the need for deoxidizing agents during melting. Write or call for new Herculoy literature: Federated Metals Division, American Smelting and Refining Company, 120 Broadway, New York 5, N. Y. Telephone REctor 2-9500, or call your nearest Federated sales office.

*Patented by Revere Copper and Brass Incorporated; alloyed and marketed exclusively to the casting industry by Federated Metals Division.

ASARCO

AMERICAN SMELTING AND REFINING COMPANY

Among the thousands of "hardware" products manufactured by the A. B. Chance Company of Centralia, Mo., are eyebolt castings for the electrical industry. These castings require a tough, high strength, corrosion resistant material with low electrical conductivity. Herculoy provided this unique combination of properties.

FEDERATED METALS DIVISION

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ALTON, ILLINOIS
Alton: Howard 5-2511
St. Louis: Jackson 4-4040

BALTIMORE, MARYLAND
Orleans 5-2400

BIRMINGHAM, ALA.
Fairfax 2-1802

BOSTON 16, MASS.
Liberty 2-0797

CHICAGO, ILL. (WHITING)
Chicago: Essex 5-5000
Whiting: Whiting 826

CINCINNATI, OHIO
Cherry 1-1678

CLEVELAND, OHIO
Prospect 1-2175

DALLAS, TEXAS
Adams 5-5034

DETROIT 2, MICHIGAN
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Locust 7-5129

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WHITING, IND. (CHICAGO)
Whiting: Whiting 826
Chicago: Essex 5-5000

IN CANADA: Federated Metals Canada, Ltd.
Toronto, Ont., 1110 Birchmount Rd., Scarborough, Phone: Plymouth 73246

Montreal, P.Q., 1400 Norman St., Lachine, Phone: Melrose 7-3591

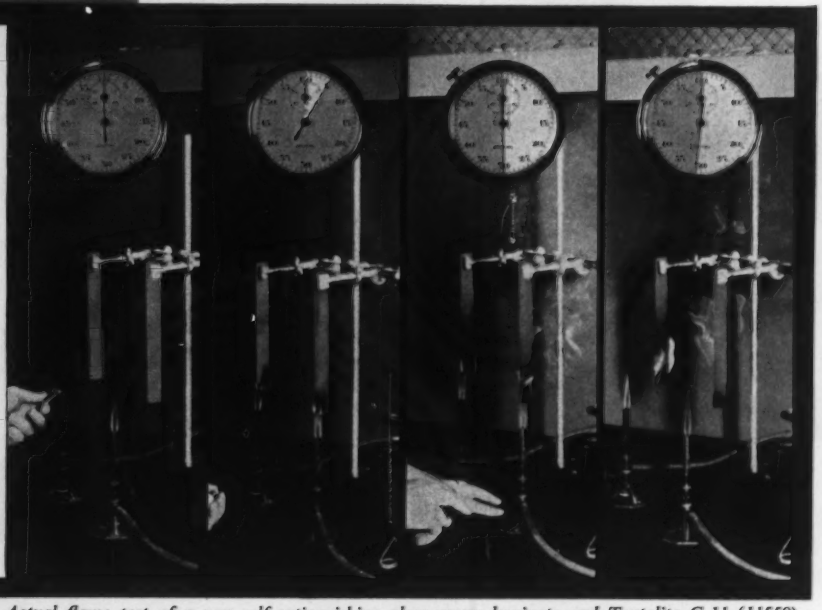
For more information, turn to Reader Service card, circle No. 407

Textolite® / reliability

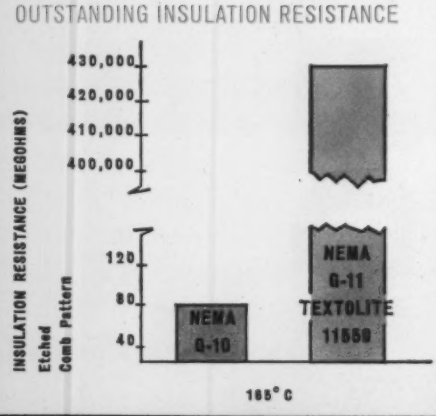
for computer and military electronics

A BUILT-IN FIRE EXTINGUISHER

Textolite® G-11 11559
self-extinguishing laminate



Actual flame test of a non self-extinguishing glass-epoxy laminate and Textolite G-11 (11559) glass-epoxy laminate. Less than two seconds after removal of burners, flame on 11559 dies, the other glass-epoxy laminate continues to burn.



Reduce fire hazard. This problem confronts many designers of computer and military electronic systems, especially where banks of circuit boards are required. Their solution . . . specification of G-11, self-extinguishing G-E TEXTOLITE 11559 glass-epoxy for printed circuits and structural electrical insulating material. Laboratory tests more severe than Standard ASTM flame tests prove Textolite 11559 flames-out within two seconds —never presents a fire hazard.

Easily exceeding requirements for NEMA G-11 laminates and specifications MIL-P-18177 Type GEB, transparent 11559 is available unclad or clad with 1 or 2 oz. copper on one or both sides. It surpasses other G-10 and G-11 laminates in its electrical properties at higher temperature ranges. Specifically, it provides low power factor, low dielectric constant and high insulation resistance into the 150° C range. Since it is highly resistant to solvents and etching solutions, rejects are considerably reduced.

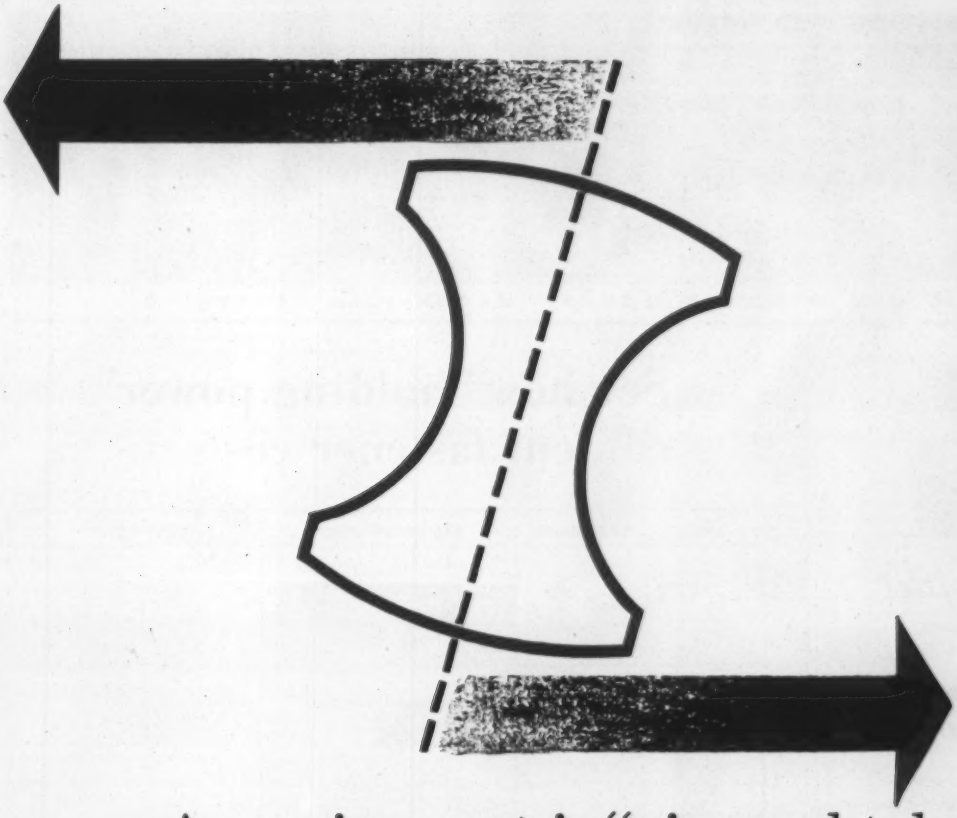
For more information on 11559, consult Sweet's Product Design File, Cat 2b/Gen., or write: Laminated Products Department, Section MD-70, General Electric Company, Coshocton, Ohio.

Progress Is Our Most Important Product

GENERAL ELECTRIC

COSHOCTON, OHIO

For more information, turn to Reader Service card, circle No. 436



An assignment in "give and take"... for Lukens Application Research.

Researching the steel that best fits the job is a matter you can safely trust to Lukens Application Engineers . . . whether your problem is metal expansivity, cryogenics, abrasion, structural stress or the complexities of corrosion. A recent and typical assignment was to determine the most efficient material on which to cradle the bearing members of a bridge. These mechanisms provide the "give" that keeps a bridge structurally sound. Since corrosion-resistance was a major goal, stainless steel seemed well-suited—but costly. Lukens, with its broad fund of practical metallurgical knowledge, suggested—then thoroughly tested—the less expensive stainless-*clad* steel. The success of this engineered combination of clad and backing steel has since been borne out by a host of clad steel bearing plate applications.

If you have an assignment in metals application, let it be our assignment too. Write Manager, Application Engineering, Services Building, Lukens Steel Company, Coatesville, Pennsylvania. Also contact us for Bridge Bearing Plate Bulletin No. D-60.

HELPING INDUSTRY CHOOSE STEELS THAT FIT THE JOB

LUKENS STEEL

For more information, turn to Reader Service card, circle No. 375

Technical-ities

By Fred E. Graves

No difference between hex and cap screws

It's not the *name* of a standard fastener that determines whether to use it for a particular application, but vice versa. The *application* requirements for strength and tolerances dictate the fastener.

Thus, if you have a joint that calls for certain tolerances in a screw, obviously the one which satisfies those tolerances is the right fastener.

IDENTICAL STANDARDS

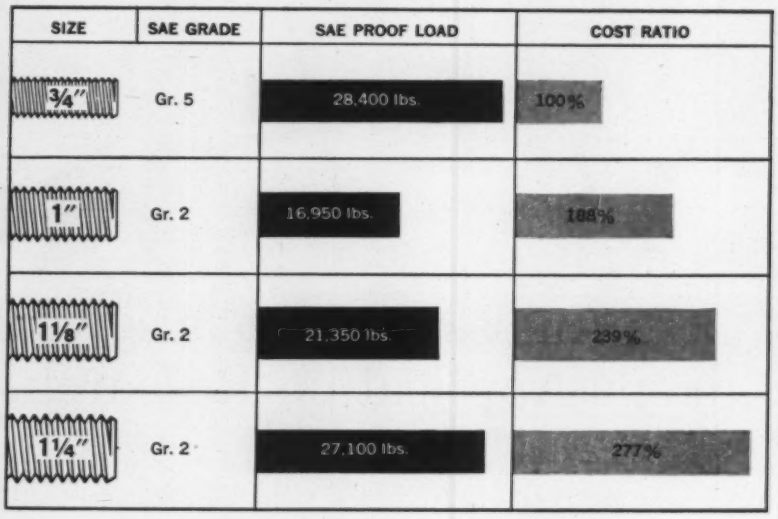
In the case of cap screws and hex screws, the standards will show you that these are merely different names for the same product. They're actually made on the same machines, to identical tolerances, and from identical materials.

No reason then to differentiate. For tapped holes, merely specify Hex Screws (SAE Grade 2) or High Strength Hex Screws (SAE Grade 5), and you'll get the *right* fastener with the quality needed.

For bolted joints, these same items are supplied with nuts when specified.

This should suggest a way you can extend standardization in your plant . . . and benefit from our new simplification of nomenclature which calls *any* fastener with head on one end and threads on the other a *screw;* and a screw plus nut a *bolt.*

See how "holding power" can cut fastener costs



Since the usual job of a threaded fastener is to hold an assembly tightly together, its *clamping force* is what you're really utilizing. This seems obvious. But how best to get the clamping force needed for the joint design? Not so obvious. Looking at size alone can be misleading . . . *and quite costly,* as the chart above demonstrates.

HOLDING POWER MEANS MORE THAN SIZE

SAE "proof load" of four different hex screws of standard steels, along with typical cost ratios, are compared. Almost unbelievable, isn't it? Yet it's a fact that the smallest of the group—the heat treated SAE Grade 5 *RB&W High Strength Hex Screw* exceeds all the others in load capacity. It can be used in place of any of the others in most normal usages.

Since it's smallest and therefore weighs the least, it also costs less... 64% less than the 1¼-inch grade 2 hex screw; 58% less than the 1⅛-inch; 46% less than the 1-inch. And since holes can be made smaller, there are also the savings in production drilling . . . and possibly in materials, too.

DESIGN ADVANTAGE

Remember, too, that smaller fasteners are more easily torqued to higher preload levels . . . which helps keep joints tight, makes them more vibration-proof.

If you would like to explore this approach to fastener economy and better utilization of "holding power," consult with an RB&W specialist. Let him contribute his fastener knowledge to your design and production needs. Russell, Burdsall & Ward Bolt and Nut Company, Port Chester, N. Y.

Plants at: Port Chester, N. Y.; Coraopolis, Pa.; Rock Falls, Ill.; Los Angeles, Calif. Additional sales offices at: Ardmore (Phila.), Pa., Pittsburgh; Detroit; Chicago; Dallas; San Francisco.

For more information, turn to Reader Service card, circle No. 360

Insulate to 2000°F. with REFRASIL

This may be the SPECIAL INSULATION you're looking for!

REFRASIL PHYSICAL PROPERTIES:

- Chemical resistance of pure silica
- Resists temperatures up to 3000° F. under certain conditions
- Low Thermal conductivity
- Fiber diameter .00020-.00040 in.
- Specific heat .19 (Batt)
- Thickness .14-.15 in. (Batt)
- Surface density .05 lb./sq. ft. (Batt)

REFRASIL USES:

- 2000° F. continuous high temp. insulation
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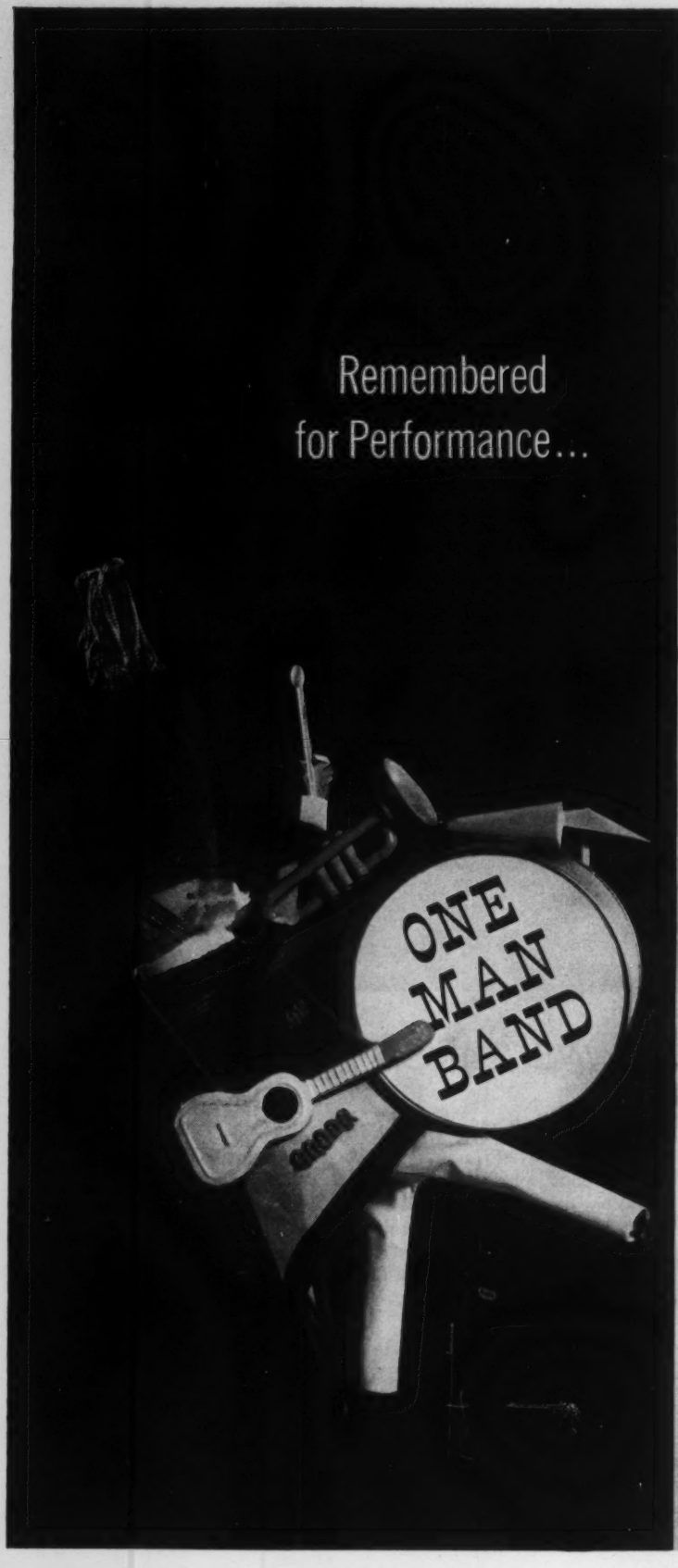

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CYMEL 3135 – 3136 (glass-filled) Additional distinctive properties: outstanding electrical properties; high impact resistance; extraordinary flame resistance; good dimensional stability. Typical applications: circuit breaker boxes; terminal strips; connectors; coil forms; stand-off insulators. Specifications: Cymel 3135 (MMI-30, MIL-M-14E, Federal L-M-181 Type 8; ASTM D704-55T Type 8); Cymel 3136 (MIL-M-19061, MMI-5).

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CYMEL 1077 (alpha cellulose-filled) Additional distinctive properties: Surface hardness, heat resistance, unlimited color range. Typical applications: appliance housings, shaver housings, business machine keys. Specifications: MIL-M-14E – Type CMG (in approved colors); Federal L-M-181 Type 1; ASTM D704-55T Type 1, SPI SPEC NO. 30026.

CYMEL 1500 (wood flour-filled) – CYMEL 1502 (alpha cellulose-filled) Additional distinctive properties: Good insert retention. Typical applications: meter blocks, ignition parts, terminal strips. Specifications: Cymel 1500 (MIL-M-14E Type CMG, Federal L-M-181 Type 6, ASTM D704-55T Type 6); Cymel 1502 (MIL-M-14E Type CMG, Federal L-M-181 Type 7; ASTM D704-55T Type 7.

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Weld failures cut 89% using vacuum-melted filler wire

[*Weld tests on alloy steel wire used in missile applications revealed nine times as many failures with air-melted wire as with Cannon-Muskegon vacuum-melted wire.*] [*Superior to consumable-electrode melting, Cannon-Muskegon vacuum-induction melting greatly reduces gas levels (nitrogen less than 25 ppm, oxygen less than 25 ppm, hydrogen less than 5 ppm). Combined sulphur and phosphorus run less than .015%.*]

[*These remarkably low gas and impurity levels can be most efficiently obtained with Cannon-Muskegon vacuum-induction melting. You are invited to write Cannon-Muskegon for further details.*]

☛ *Among test samples prepared from air-melted wire, 18 out of 32 failed at the weld.*]

☛ *Among similar samples prepared from the vacuum-melted wire of the same grade, only two out of 32 bars failed at the weld.*]

[*Different alloys of Cannon-Muskegon vacuum-melted welding wire are available in sizes from 1/32" to 1/8", in 36" cut lengths, or in 10 or 25-lb. spools packed in airtight Argon-filled steel containers.*

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Flame sprayed metal increases wear resistance better than 10 times

AIDS WEIGHT REDUCTION

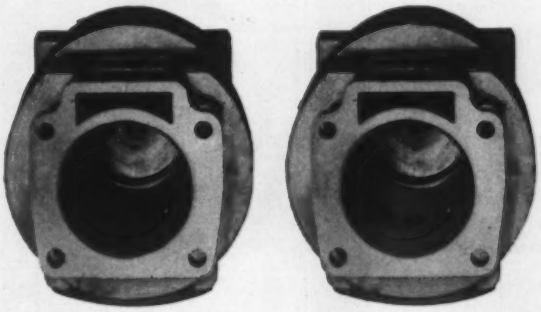
Automatic setup for metallizing inner walls of aluminum cylinders used in lightweight gasoline engines. Cabinet in foreground houses six-station rotary setup; automatic control panels are at right.

Many methods, including cast-iron cylinder liners and chrome plating, have been tested for wear resistance in lightweight gasoline engine blocks of aluminum.

Best of these methods experienced breakdowns in less than 400 hours. Now they are metallized with METCO Sprabond (molybdenum alloy) as a bonding agent, followed by a coating of sprayed steel alloy.

Test runs of over 4,000 hours show little or no wear of the metallized surface. Finish thickness is .007"; weight – a few grams. Cast-iron liners weighed almost ½ pound.

Cylinder at left machined ready for flame spraying; one at right has been metallized and hone finished.



Closeup of automatic six-station rotary setup. Cylinders are individually rotated at 150 rpm. Cylinder is loaded on table at Station 1, moved through Stations 2 and 3 for pre-heating by torch. At Station 4, bonding coat is applied by the gun nozzle which feeds into the rotating cylinder. Low alloy steel is applied at Station 5 and cylinder cools at Station 6. Cylinder walls are finished by honing.

New engineering data bulletin

Bulletin 136B—The METCO Flame Spraying Processes, provides basic engineering and application data on flame sprayed coatings of metals, ceramics, carbides and other high melting point materials. 16 pages. Send coupon for free copy.

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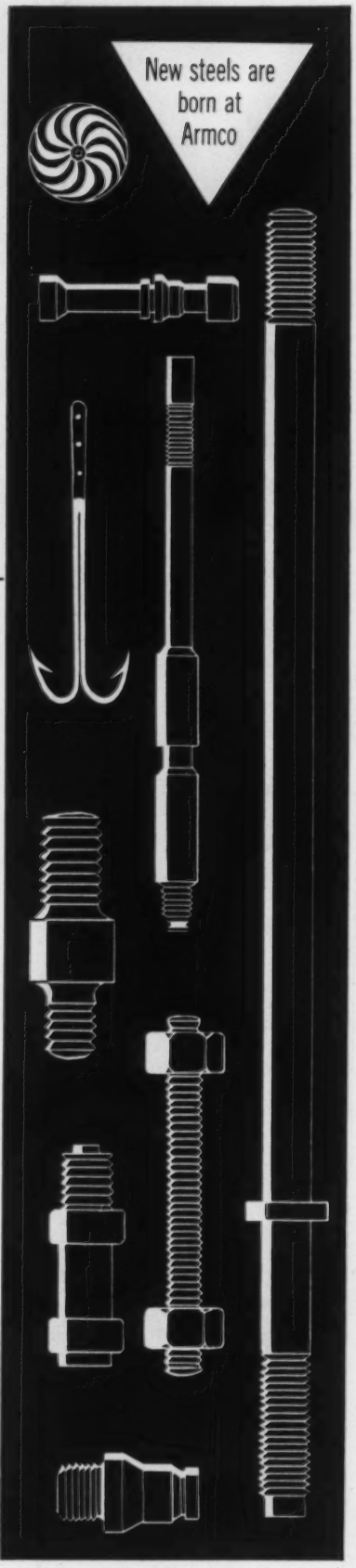

Armco 17-4 PH Stainless Offers You 7 Big Advantages

Combines High Strength; Resistance to Corrosion, Galling, Abrasion, Fatigue, Heat; Simplifies Production

Armco 17-4 PH gives you this array of advantages because it has such an unusual combination of mechanical properties, corrosion resistance, and fabricating characteristics. Here are a few that have made this special Armco stainless steel useful in so many applications:

Ultimate tensile strength—200,000 psi*
Tensile yield strength—185,000 psi*
Elongation, % in 2 in.—14*
Hardness, Rockwell—C44*
Endurance limit, 10^6 cycles—90,000 psi*
Short time ten. yld. str. at 800 F—141,000 psi*
Corrosion resistance—Equal to Type 302 Stainless in most media
Heat treatment—1 hour at 900 F for highest strength and hardness
*Typical properties in Condition H 900

Armco 17-4 PH has been the answer to perplexing design problems in a diverse range of applications such as fishhooks, surgical tools, missiles, shoe machinery, valves and atomic reactors. It has replaced carbon steels, austenitic and martensitic stainless steels, and non-ferrous alloys because it gives better performance and frequently lowers production costs.

Because 17-4 PH stainless can be heat treated by only 1 hour at 900 F, parts can be finish machined in the easy-to-work solution treated condition. Expensive descaling, straightening, and secondary machining or grinding operations can be eliminated.

Consider how the unusual properties of Armco 17-4 PH Stainless Steel can be used to solve your design problems and improve the value of your products. Write us for complete information. Armco Steel Corporation, 1870 Curtis Street, Middletown, Ohio.

ARMCO STEEL

Armco Division • Sheffield Division • The National Supply Company
Armco Drainage & Metal Products, Inc. • The Armco International Corporation • Union Wire Rope Corporation

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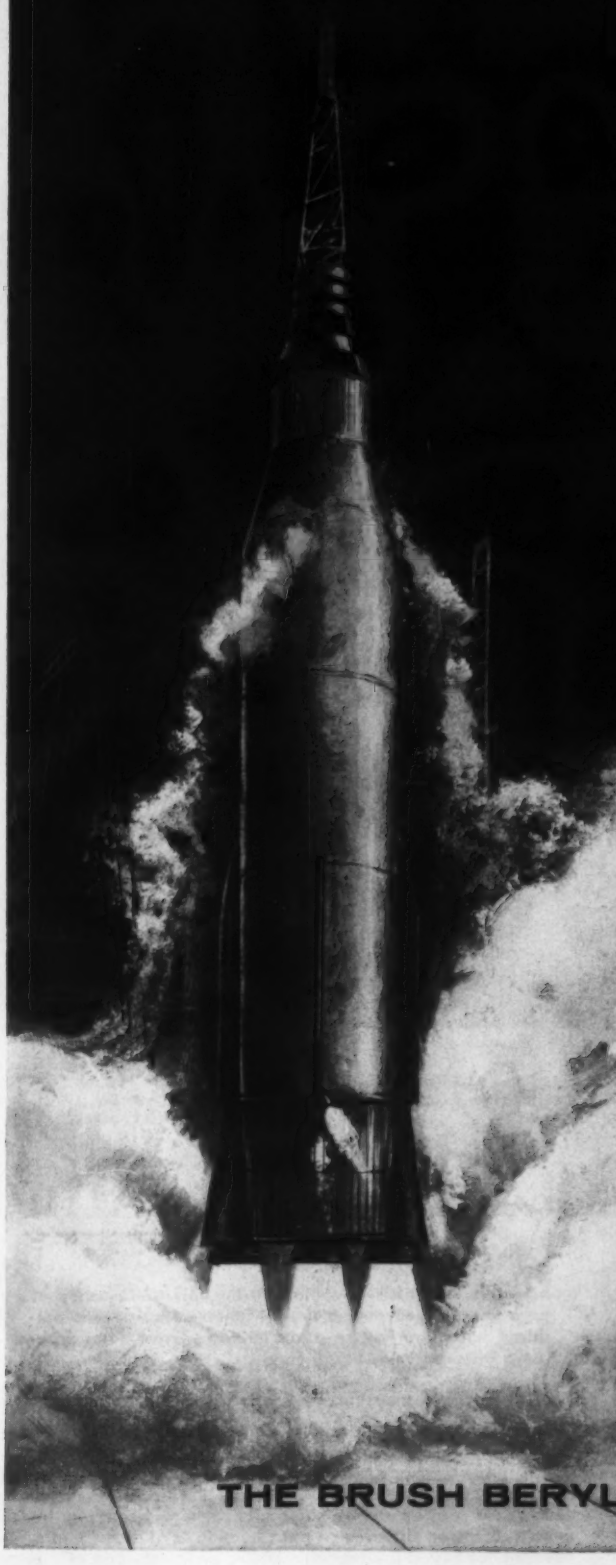
SIGNIFICANT ADVANCES IN BERYLLIUM TECHNOLOGY COME FIRST FROM BRUSH

FORGING INTO SPACE

Beryllium heat sinks are being readied for test flights.



Right now scientists and engineers from the National Aeronautics and Space Administration and McDonnell Aircraft are working toward the day when the first American will ride into space to orbit the earth.

How do beryllium and Brush fit into the Project Mercury manned space flight effort? A beryllium heat sink is one of two ways being tested to protect the precious human payload from re-entry heat. Beryllium absorbs tremendous heat, is light, yet maintains strength at high temperature. And Brush developed new techniques to produce the world's largest beryllium forgings for use as heat sinks in the tests to determine the final design of the manned space capsule.

Beryllium offers the solution to many 'space age' application problems. Brush will continue to take the lead in producing beryllium in new forms by new techniques for new uses.

Can this metal, its alloys, its oxide, or our expanding experience with these versatile materials solve a problem for you? Let us try. Contact us at 5209 Euclid Avenue or ENdicott 1-5400 in Cleveland, Ohio.

THE BRUSH BERYLLIUM COMPANY

For more information, turn to Reader Service card, circle No. 464

"Music's most glorious voice"...perfected by Hammond Organ Company

Where no metal but Palladium

In any keyboard musical instrument easy operation and precise response to the artist's "touch" is all-important.

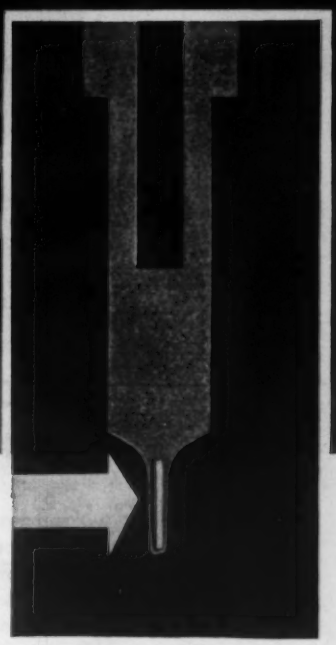
Palladium, in the form of 1296 small cross-wire electrical contacts in the standard Hammond two-manual organ, faithfully and reliably transmits the artist's touch. As the key is depressed nine lightly loaded spring finger contacts select the harmonics and the musical interpretation is instantly carried to electronic equipment which, in a blending of art and science, produces "music's most glorious voice".

Hammond uses pure palladium as a wire face on nine bus bars that extend the entire length of the keyboard. An alloy of palladium and ruthenium is used on the contact spring fingers to insure trouble-free operation. The non-tarnishing and wear-resisting palladium contacts produce high fidelity response, even with a low operating voltage and a feather-touch. No other metal has been found to do this as economically.

In accelerated tests of contacts using this combination of pure and alloyed palladium, a lifetime of music was produced without a failure—forty million perfect notes without a distorted one.

It could pay you to use a platinum metal

Your problem might be readily and economically solved with platinum metals—where reliable make and break electrical contact is indicated, such as in low noise, high fidelity transmission ...where wear-resisting, non-tarnishing surfaces are required, such as for printed electrical circuits...where a combination of severe corrosion and erosion must be met, as in the case of spinnerettes for rayon production...where peak catalytic efficiency is required as in the refining of high octane gasoline...where underwater hull protection is a problem...or where product purity must be retained despite high temperatures, as in the



Only a platinum metal does it. Individual contact fingers (this illustration shows one, enlarged) are fitted with ⅛ inch lengths of 0.005 inch diameter palladium alloy wire. These fingers work against pure palladium wire-faced bus bars which extend the length of the keyboard. An important supplier of wire and other forms of the platinum metals is Engelhard Industries, Inc., Newark, N. J.

will do the job as well...

For more information, circle No. 384

case of lens glasses... the platinum metals have proved to be the most economical for certain critical equipment.

Industry is going to higher temperatures and higher pressures. Perhaps your own progress has been blocked by the limitations of materials to withstand such severe conditions. The platinum metals have removed many barriers. Have you considered them for your problems?

Platinum, palladium, rhodium, ruthenium and iridium have unique potentials, well worth your attention. Specialists are prepared to work closely with you in evaluating these metals for new commercial and scientific uses.

As a first step, write us for additional data on the outstanding characteristics and successful applications of the six platinum metals and their alloys—indicating your field of interest or how we might be of assistance.

Can these properties of the Platinum Metals help you?

Superior Wear Resistance
Exceptional Chemical Inertness
High Temperature Stability
Peak Catalytic Activity
Low Vapor Pressure

The six platinum metals are:

PLATINUM
PALLADIUM
RHODIUM
RUTHENIUM
IRIDIUM
OSMIUM

INCO **PLATINUM METALS DIVISION**

The International Nickel Company, Inc., 67 Wall Street. New York 5, N.Y.

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STST*

*Superior Tool Steel Tubing

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Superior tool steel tubing is an excellent material for tools, but equally good for 1001 other applications. Odds are that it will cut costs and improve performance wherever it is used. Type E-52100, an oil hardening grade of high-carbon and chromium alloy steel, has been widely used for such diverse applications as thread guides on hosiery knitting machines, nylon yarn guides, ball bearing races, nozzles for blast cleaning equipment, gear and pinion parts, dental instruments and extrusion mandrels. Type E-1095, a high-carbon steel tubing, is serving as applicators for jewelers' oilers, leather and paper punches, and surgical instruments.

Perhaps you have an application that can benefit from high strength and hardness, good wear resistance, abrasion resistance, shock resistance, and notch toughness. In that case, consider Superior tool steel tubing before you go any farther. It could give you a better product at a lower cost. Send for Data Memorandum #14, a handy guide to your thinking. Superior Tube Company, 2006 Germantown Ave., Norristown, Pa.

Steel

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All analyses .010 in. to ⅜ in. OD—certain analyses in light walls up to 2½ in. OD

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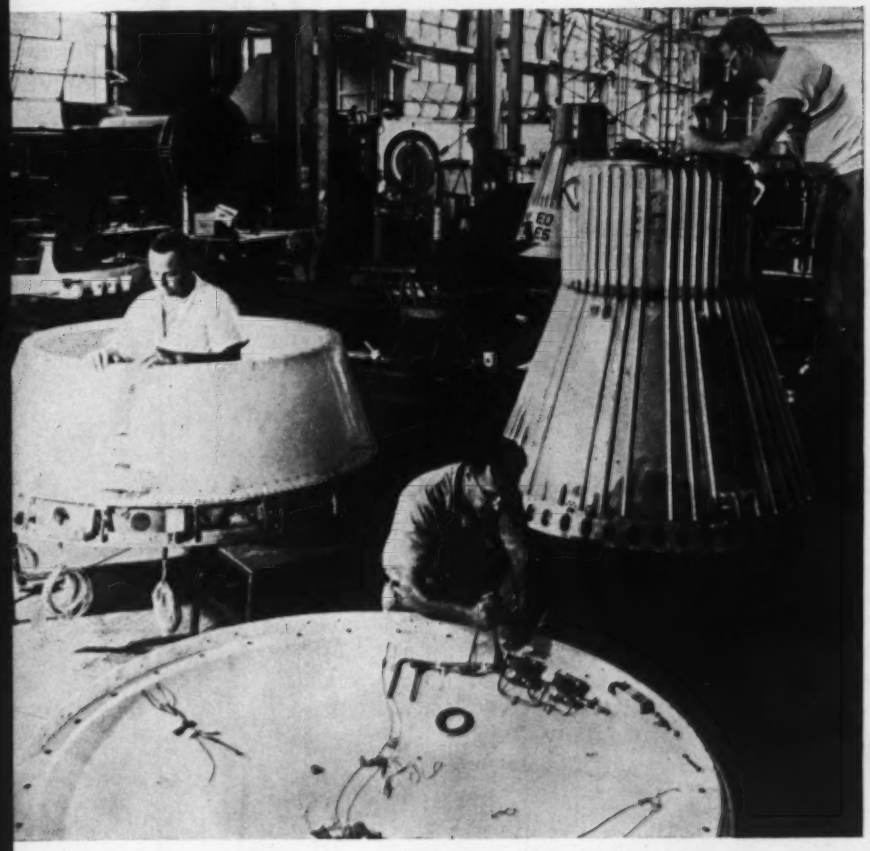
Product-Design
BRIEFS
from Durez



MORE ABOUT UNCLE'S MONKEY

Uncle Sam's first astronaut was a rhesus monkey, also named Sam, who took a 55-mile-high ride in a vehicle called Little Joe. It is Little Joe we're concerned with.

Specifically, with the part of Little Joe made from heat-resistant Hetron® polyester resin.

The full-scale Little Joe capsule is 9½ feet tall, 20 inches across the top and 6 feet across the rounded base. The bottom portion of this capsule consists of a heat-absorbing shield of glass-reinforced Hetron. Its several layers add up to an inch of thickness.

Hetron was chosen after intensive research because it provides an unusually high degree of inherent heat resistance, heat stability and fire resistance. All of these properties are important in coping with heat generated by atmospheric friction at escape velocity. Ease of fabrication was pretty important, too.

The large photo shows the two Hetron portions of the capsule: the bottom, in foreground; the heat-shield, at left.

Not only Uncle Sam's sophisticated scientists, but also the more prosaic industrial designers are interested in Hetron. It offers great promise in many different applications.

For example, it makes possible small boats that are fire-retardant. Because it is highly resistant to many acids, it finds wide use in scrubbers, ductwork and similar places where corrosive fumes quickly destroy other materials. It's being used for skylights on piers. One company even enclosed an entire building with it.

Hetron can by no means be considered a cheap substitute for other materials. Designers have been impressed with it and have used it simply because it performs its function better than any other material they might have used. Sometimes it costs less than other materials. Sometimes it costs more. But, in either case, it does things better, longer or more safely than anything else. We've got a data file on it if you're interested. Ask for Hetron File A.

For more information, circle No. 444

A THOUGHT FOR USERS OF DIE CASTINGS

When you put these seven parts together, you get a highly efficient low-cost pump for emptying drums of gasoline, lube oil or chemicals.

The manufacturer used to die cast these parts. Now he has them molded from a Durez phenolic. The switch to molding from die casting eliminated many finishing and assembly operations. Even the fine threads on one of the parts were flawlessly molded.

The switch to phenolic from aluminum added greater corrosion and chemical resistance. Being non-metallic, phenolics also prevent sparking and minimize the risk of handling volatile liquids.

For more facts about molding with versatile Durez materials, ask for Bulletin D400.

For more information on Durez products mentioned above, check here:

- ☐ Hetron polyester resins (File A)
- ☐ Phenolic molding compounds (illustrated Bulletin D400)

Check, clip and mail to us with your name, title, and company address.
(When requesting samples, please use business letterhead.)

DUREZ PLASTICS DIVISION

1406 WALCK ROAD, NORTH TONAWANDA, N. Y.

HOOKER CHEMICAL CORPORATION

HOOKER CHEMICALS PLASTICS

Stainless steel

lifts things above the ordinary! Stainless steel reflects gleaming beauty—*solid* beauty! It won't peel . . . and it resists heat, dents, scratches and corrosion. In fact, no other commercially available metal endures like stainless. No wonder designers and consumers all like it! And remember: The *best* stainless steels are made with Vancoram Ferroalloys! Vanadium Corporation of America, 420 Lexington Avenue, New York 17, N. Y. • Chicago • Cleveland • Detroit • Pittsburgh

VANADIUM
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Producers of alloys, metals and chemicals

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ENGINEERING & DESIGN

...AT A GLANCE

Metal filament wound plastics structures now being evaluated by the aircraft industry are highly promising. Exceptionally high tensile strength (315,000 psi) and modulus (20.3 x 10^6 psi) values have been obtained developmentally for unidirectional laminates using 94% steel wire (0.005 in. in dia) by weight in an epoxy binder. Problem: even with these high values, strength-to-weight ratios are still lower than those of glass filament wound structures. However, these strength and modulus values may be extremely interesting to designers and materials people working in areas other than aircraft.

Source: Aerojet General Corp., 6352 N. Irwindale Ave., Azusa, Calif.

Stainless steels with improved corrosion resistance can be obtained by alloying with cobalt. Tests show that chromium stainless steels containing 1.5 to 10% cobalt have less susceptibility to intergranular corrosion after aging in sulfuric acid than unalloyed chromium stainless steels.

Source: Cobalt Information Center, Battelle Memorial Inst., 505 King Ave., Columbus 1, Ohio.

A method for accurately measuring coating thickness on the inside of small diameter tubes consists of using two miniaturized gages that measure eddy currents induced in the coating. The measurements are nondestructive and are localized to a small area. The gages, although designed primarily for measuring thickness of chromium electroplates in the bores of small gun barrels, can be adapted for determining thickness of other types of coatings on the inside of any small tube.

Source: V. A. Lamb and P. A. Krasley, National Bureau of Standards, Dept. of Commerce, Washington 25, D. C.

The lubricating properties of graphite are due to microscopic layers inside the graphite crystal that "roll up like window shades" and act like roller bearings, recent research indicates. Also, the research shows that graphite's lubricating properties change with varying conditions of temperature, pressure and humidity. These changes are said to be more easily explained by the new "roll up" theory than by the previous "slide" theory which says that graphite layers slide over each other like a slippery deck of cards.

Source: W. Bollmann and J. Spreadborough, Battelle Memorial Inst., Geneva, Switzerland.

Glass-reinforced plastics pipe is a promising substitute for steel pipe in a variety of petroleum applications, a recent producer's study shows. Field tests showed that glass-reinforced plastics pipe is far superior to steel pipe in resisting paraffin deposition at temperatures down to –40 F. The tests also showed that glass-reinforced plastics pipe was unaffected by salt water after being in service for almost three years under 900 psi pressure.

Source: R. M. Levy and B. M. Vanderbilt, Esso Research & Engineering Co., Linden, N. J.

Nitriding gives high surface hardness to unalloyed titanium but greatly reduces impact strength of a titanium alloy containing 6% aluminum and 4% vanadium, according to recent research. Fuel control valves for jet engines have been experimentally produced from unalloyed titanium and nitrided with excellent results.

Source: J. R. Cuthill and others, National Bureau of Standards, Dept. of Commerce, Washington 25, D. C.

METALOGICS AT WORK

How Ryerson helps stainless user cut costs

Production costs for a manufacturer of stainless steel fittings were high—and rising. Parts were being machined from 1-inch round, cold drawn Type 304. Its relatively slow machining speed made blanking, drilling, threading and roughing out slow and costly. Management considered that switching to 30% faster machining Type 303 would bring costs back in line. **A BETTER ANSWER:** this boost in machining rates looked like a good answer—but was it the *total* solution? With their Ryerson Representative they studied the problem further, and realized that service demanded of their fittings didn't require all the corrosion resistance of the 300 series. On the recommendation of Ryerson, they switched to Type 416 and gained *two* ways. It gave them a much higher machining rate—*100%* faster than type 304—*and* saved many dollars a ton in material costs.

There may be another stainless that will do *your* job faster, better, at lower cost. Ryerson offers *more* types, shapes, sizes, tonnage—and the knowledge of when and where to use them. Ryerson can handle your mill orders, too—saving you time and trouble at no additional cost.

Always be "Metalogical"—call Ryerson.

METALOGICS

STEEL • ALUMINUM • PLASTICS • METALWORKING MACHINERY

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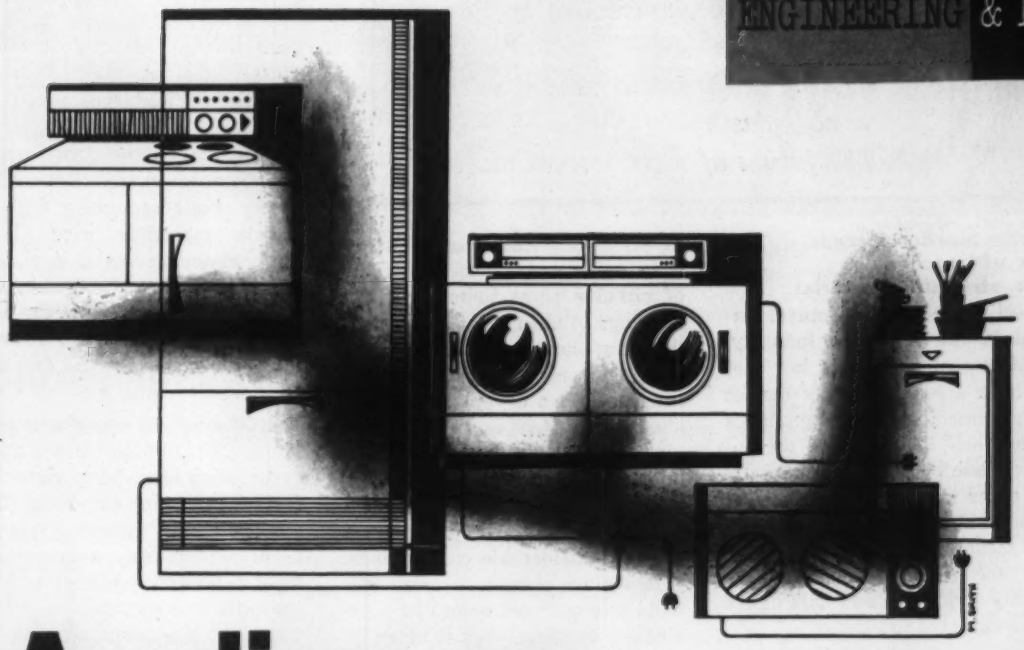


Appliances:

What Materials Are Next?

by **Robert J. Fabian,** *Associate Editor, Materials in Design Engineering*

Appliance engineers are encountering many critical problems in materials selection. This article, based on a field survey, tells how they are solving these problems by adopting new materials and by making more efficient use of conventional materials. Covered are:

Structural Materials
Decorative Trim and Hardware
Coatings and Finishes
Insulation
Materials for Cooling and Heating

M/DE Special Report No. 171—June, 1960

Structural materials

- *How alert designers are cutting steel costs*
- *Lots of development needed with reinforced plastics*
- *The future of sheet formed plastics*

Despite plastics inroads, steel will remain basic structural material

Steel is the basic structural material in the appliance industry. Its ideal combination of low cost and high strength simply cannot be surpassed for most appliance applications and, despite the inroads made by plastics, aluminum and other structural materials, it will undoubtedly remain the dominant structural material. An average major appliance contains roughly 80% steel and this figure is not expected to change.

Two important questions constantly posed by steel users in the appliance industry are:

1. Once bought, how can we use the material more efficiently and keep costs down?

2. How can we improve its appearance and resistance to various environments?

Solutions to the latter problem primarily involve the use of surface coatings and finishes and are the subject of a later section. For purposes of this discussion let's focus our attention on ways to reduce cost.

Using the metal efficiently—Assuming that a part is designed to use the minimum amount of metal consistent with its function, the next logical cost reduction step is to cut down scrap losses. Appliance designers, like other designers, are always striving to get as many parts out of a sheet as possible. Scrap is customarily sold, but designers are taking a closer look to see how it can be used to make other parts.

A good deal can be gained from this approach. For example, one appliance manufacturer is now welding small scrap pieces into larger pieces which are subsequently fabricated into blower housings. The same manufacturer is using cut-outs from the middle of circular parts to make pulley housings. And in still another dramatic application he has found a way to make built-up counterweights (for a dryer) from scrap steel instead of cast iron. This may not seem significant but when multiplied by thousands of appliances it has enabled him to eliminate over 1,250,000 lb of cast iron at considerable cost savings.

Reducing shipping costs—Offhand this may not seem like a designer's problem—but it often is. For example, one appliance engineer, after learning that coil steel was cheaper to buy and ship than sheet steel, made a rigorous analysis to see if he could make his products from coil instead of sheet. He learned that he could readily slit, cut and flatten the coil into tailor-made sheet. Thus, he no longer has to stock different sizes of sheet and his inventory is easier to control. Furthermore, the coils can be used directly in blanking presses.

What about low-pressure plastics laminates?

Designers of major appliances are ever-alert to the possibilities of glass-reinforced plastics and have fully evaluated their prospects for wrappers (housings). However, at today's state of the art the materials are not feasible for external use. Glass-reinforced polyester materials are relatively expensive and do not lend themselves to mass production (many appliance manufacturers talk in terms of at least a thousand units a day).

Furthermore, the appearance of the materials leaves something to be desired. Discoloration occurs after aging and the materials tend to acquire a rough texture as the surface resin wears away and the fiber strands are exposed.

Dishwashers appear to be a good starting point when and if glass-reinforced plastics become feasible for external use. They have already been tried for dishwasher lids but have not worked out because sharp corners and bosses created problems with the premix materials used. Using these materials inside appliances offers much more promise. One leading manufacturer is currently investigating a premix glass-reinforced polyester for the front tub of a washer line.

Still another manufacturer is going into production on a new dryer using some large glass-reinforced polyester air ducts. This material will replace presently-used galvanized sheet. Some trouble was encountered with objectionable odor and in getting the right fire resistant material. However, these problems have been solved and it looks as though Underwriters' approval will be obtained. Furthermore, the ducts will probably cost less than galvanized in addition to having greater design flexibility.

Sheet formed plastics are replacing sheet metal

Sheet formed plastics parts first achieved a strong foothold in the appliance industry with the successful development of refrigerator door liners. This is an important application, but no dramatic new uses for these materials are on the horizon. Although ideal for door liners and breaker strips, their limited structural strength may prevent use for many other appliance parts.

Two problems right now are cost and materials compatibility. Although polyethylene liners are also used, the dominant material is modified polystyrene. This material performs admirably but its further use in refrigerators does not appear too bright. Foaming agents used with the new urethane foams tend to attack polystyrene. Consequently, despite its higher cost, users may have to switch to an ABS plastic.

Westinghouse Electric Corp.

Opaque nylon lid *had to be used on this new hot dog cooker appliance because clear cellulose acetate material would not pass Underwriters' test.*

Westinghouse Electric Corp.

Open-pore polyurethane foam *was recently selected for air conditioner filter because of its high filtering capacity, washability, unique germicidal properties, and ease of handling.*

Materials with special functional properties

- *Designers would like plastics that can be used at higher temperatures*
- *Critical need for inexpensive plastics that will not burn*
- *Still some corrosion problems with die castings*

Materials to resist heat and fire

There is a great need in the appliance industry for plastics with high heat distortion temperatures that will meet Underwriters' requirements. This need has been created mainly because of the development of new high temperature appliances. Phenolics perform adequately in such appliances but they have limitations. Designers would like materials that have even better heat resistance and are available in a much wider range of colors.

Underwriters' requirements hard to meet—New Underwriters' restrictions on the use of inflammable plastics are a real sore spot in the appliance industry right now. Since most thermoplastics are inflammable, designers do not know where to turn for equivalent, low cost materials that will meet Underwriters' approval. This problem is especially acute with air conditioners as they ordinarily use considerable plastics hardware on the exterior. Designers may have to turn back to metals if better plastics do not come along.

As one user puts it, "There is no good answer to the problem of flame retardancy and fire extinguishing. It is something that has to be worked out." Another puts it even more bluntly: "There is no good, low cost decorative plastic that will not melt or burn."

Additives cause trouble—Many plastics can be made self-extinguishing or less flammable by using suitable additives. However, these additives can cause trouble during molding or extrusion. Formation of toxic vapors is one problem. Also, some plastics molders do not like to handle the materials because they attack dies. Furthermore, some additives make some plastics harder to push through extrusion dies. They may also interfere with the adhesion of decorative paints that are subsequently applied.

Another troublesome Underwriters' requirement that irks designers: electrical components cannot be mounted behind plastics unless they are separated by a piece of metal. This requirement can raise costs considerably, particularly with trim and consoles where a lot of plastics and electrical components are used.

Materials to resist corrosion

New uses for polypropylene—Appliance designers are finding that the low cost and high corrosion resistance of polypropylene are particularly advantageous in washing machines. One manufacturer is successfully using the material for the detergent reservoir and the rinse condenser reservoir of one washer. Although he would also like to use polypropylene on exteriors, he feels that its color and gloss are not as good as those of other plastics. However, other users do not find the appearance of the material objectionable.

Hypalon solves bleach problems—Neoprene rubber is still widely specified for washing machine hose. However, severe oxidation problems created by the new bleaches have forced some users to switch to chlorosulfonated polyethylene rubber (Hypalon). Although Hypalon performs extremely well, designers wish that it cost less. Also, one user reports that the material is difficult to mold to accurate dimensions.

Some liquids tough on die castings—Die castings create few prcblems in appliances. However,

one important problem remains—washer pump housings. These parts are not usually made of aluminum because aluminum is badly affected by detergents. And attempts to make plastics pumps have not worked out. Consequently, designers still have to use zinc. One user reports that zinc pumps will last for about 10 to 15 years in most environments. However, in certain sections of the country they have to be changed continuously. This seems to be a common problem and there is no low cost solution in sight. Evidently surface treatments do not do much good since they wear away quickly.

Because of corrosion and other factors, many appliance manufacturers are experimenting with Delrin acetal moldings as a substitute for die castings. Preliminary results are promising and there is no question that the material will soon be making sharp inroads into traditional die casting applications.

Corrosion problems with aluminum—Some of the corrosion problems reported with aluminum are surprising as one tends to associate the material with good corrosion resistance. However, these problems are admittedly unique.

One refrigerator manufacturer reports he is currently experiencing corrosion problems with aluminum evaporators. He reports that he has to be particularly careful to prevent any copper from contacting aluminum and starting corrosion.

Another manufacturer reports that he would like to use more aluminum but is limited by corrosion problems. This manufacturer experienced a particularly bad problem with aluminum tubing carrying Freon-12 from the compressor to the evaporator. Water condensation on the tubes caused a corrosion phenomenon called "poulticing" and resulted in severe leakages. The problem was solved by painting the tubes, but not before many failures were reported.

Materials to resist wear

Use of nylon has solved many lubrication problems in appliances. In fact, one washer manufacturer reports that its use enabled him to continue with a belt drive that he thought he would have to discontinue because of wear problems.

Designers are taking a close look at Delrin as a replacement for nylon because of its superior hardness and its freedom from moisture absorption problems. One user reports that he has to boil nylon parts for 48 hr after they come out of the mold or keep them in a humidity chamber for six weeks. He is thinking of switching to Delrin for washer-dryer gears and other parts.

One way users think they can reduce brittleness of nylon at high temperatures is to use a glass fiber filler. One manufacturer finds that he may be able to use glass-filled nylon as high as 350 to 400 F, as contrasted to 275 F for the unfilled material.

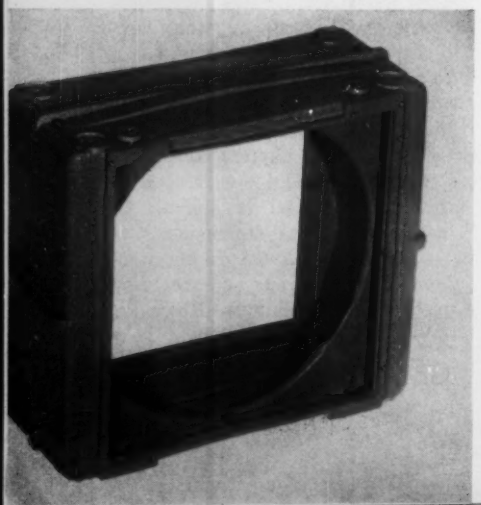
Graphite and molybdenum disulfide fillers are also good for high temperatures. These fillers are used with nylon for anti-friction applications such as rollers for built-in ovens, switch cams, and pulleys for oven counterbalance cables.

Other Materials Needed

Here is a quick check list of other improved materials that designers would like to have:

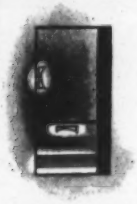
- Copper tubing that won't work harden.
- A lubricant that will not ruin paint adhesion or attack plastics.
- Wire insulation for hermetic motors that will take high temperatures without breaking down.
- Permanent magnet materials for doors that have a "longer reach," that is, exert their force at greater distances.
- Better ice release agents for ice cube trays.
- Plastics without a characteristic plastics odor.

***Polypropylene** is achieving rapid recognition in appliance industry. Unit shown here is two-piece injection molded air conditioner housing made in Italy.*
Montecatini Soc. Gen.



***Plastics** are being used in ever-larger quantities for appliances. These are just some of the plastics parts used in one 1960 refrigerator.*
Westinghouse Electric Corp.

Decorative trim and hardware



- *Need for clear, high temperature plastic*
- *Consumers like plated parts, but designers would prefer something cheaper*
- *Vinyl coverings have growing pains*

A great deal of attention is devoted to the selection of decorative trim and hardware for appliances because of its sale importance. Many consumers still buy an item primarily for its looks rather than its ability to do the job. Thus, designers are constantly searching for ways to make their products more attractive. There is a marked parallel to the automotive industry in this respect. Major structural and engineering changes are usually made every few years, but trim and hardware are changed more frequently. Many minor engineering improvements are also made periodically, provided they can be accommodated without involving major redesign.

Clear plastics not good for high temperatures

In common with other product designers, appliance designers would like to have an inexpensive, clear plastic that can take higher temperatures. Clear acrylics are fine for dials and nameplates for low temperature use but a higher temperature material is needed for ranges and similar appliances. (One user would like a material that can take 400 or 450 F, but this requirement appears higher than necessary.) The material should be easy to decorate and mark with instruction data and should be self-extinguishing.

Glass, of course, meets all high temperature requirements. However, decorations and other markings are not easy to apply. Furthermore, because of its limited formability, glass usually has to be used flat. One range manufacturer is currently using a V-shaped glass plate on his oven console, admittedly with some headaches. Forming requires an extra high temperature operation and close control is needed in the mold to make sure the panel remains true and does not cause subsequent misalignment problems.

Chromium plating still popular

Chromium plated parts are as popular as ever with consumers and thus are still widely specified for appliances. Designers have taken advantage of improved plating techniques recently announced and no problems are reported. Some users report difficulty in color matching chromium plated parts with each other and with stainless steel parts. However, while these differences may be obvious to a trained eye, they are too subtle for—and thus of little concern to—the average consumer.

Actually, some external parts that look like stainless steel are really made of brushed chromium plate. Although stainless steel is being used to some extent, designers find that chromium plate is often less expensive and has more eye-appeal. One user prefers a particular brushed chromium finish because it is not obtainable in stainless. Also, there is a feeling that the characteristic bluish cast of bright chromium is more appealing to consumers than polished stainless. Finally, users are still wary of stainless for ranges and similar appliances because of its characteristic change to a strawish yellow color when exposed to heat.

Appliance designers are also doing a lot of functional chromium plating. It is being used to increase wear resistance and provide controlled friction, and to provide corrosion resistance at high temperatures.

There is not as much use of preplated materials for appliances as one might expect. One manufacturer reports that he uses little preplated material because of its raw edge when fabricated. He also feels that too many precautions are needed to prevent the material from being damaged between the time it is received and the time the appliance is shipped.

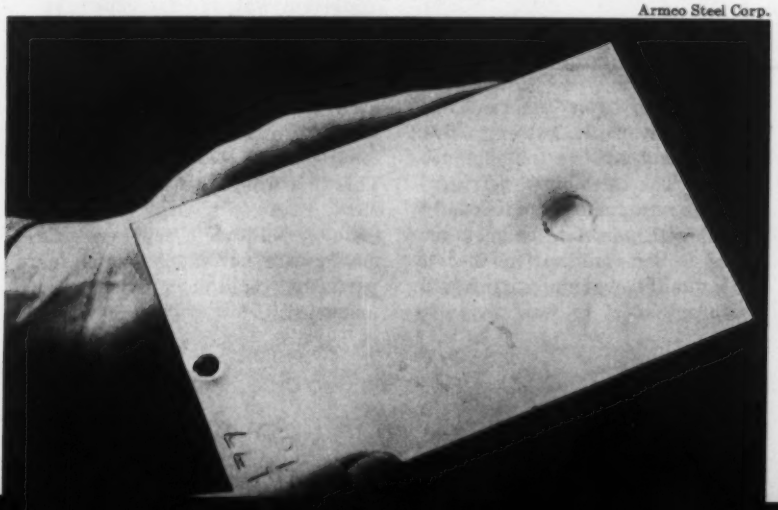
Anodized, metallized and rigidized

Appliance designers are constantly looking for an inexpensive material with a high quality appearance. This requirement has led to widespread use of anodized aluminum, vacuum metallized plastics, and embossed or rigidized metal.

Anodized aluminum has proved particularly effective because of its durability and its availability in a wide range of colors and decorative effects. Small trim parts are now being made with as many as four integral colors. However,

New one-coat porcelain enamel system *has satisfactory smooth surface and excellent bond after PEI adherence test.*

Armco Steel Corp.



as will be pointed out later, color matching and fading are still a problem.

Vacuum metallizing, too, has made rapid gains because it provides a metallic look at low cost. However, the process has to be used with care to preserve good appearance over long periods.

Rigidized metal is also expected to retain its popularity. It has proved a boon to users because, besides appealing to the consumer, it has relatively high strength for its thickness and its pattern covers up surface defects. It is easily maintained by the consumer and hides scratches, smears and other unsightly marks.

Good future for vinyl sheet and laminates

Because of the public's acceptance of the appearance and durability of vinyl coverings, appliance designers are constantly looking for ways to apply this unique material. A major breakthrough occurred several years ago when a major refrigerator manufacturer offered buyers a wide choice of vinyl covered door fronts. Although initial consumer reaction was not exceptional, an important step was made.

One leading manufacturer is currently using an adhesive-bonded vinyl sheet on the upper half of one refrigerator line. Although some problems were experienced with shrinkage and contraction of the sheet, they were solved by using an extra wide border strip. The same manufacturer is also using a vinyl-metal laminate for the first time on his 1960 refrigerators. High hopes are held for this development as it gives the consumer a wide choice of color and texture. The laminated panels are separately stocked by the dealer and easily slipped into place after the consumer makes his choice.

Most of the production and welding problems with vinyl-metal laminates have been solved. However, edge corrosion is still a problem, especially in salt air environments. One manufacturer reports that use of the laminate on one of his range lines had to be stopped because of this problem.

Packaging Materials

One of the real sore spots with appliance designers is the high cost of packaging. One manufacturer reports that relatively simple cardboard containers are costing him from $5 to $10; another user is reportedly paying about $3. This is what the manufacturer pays and, counting mark-ups, the ultimate cost to the consumer is even higher.

At present these prices appear irreducible, since cardboard is among the cheapest materials. Users are experimenting with foam packagings, but this approach does not appear economically feasible. In some cases packaging has been eliminated entirely by shipping appliances in collapsible metal frames. However, this approach can only be used in special situations. Reusable containers have also been tried, but the problems of damage and return shipping costs proved insurmountable. Thus, it looks as though users will have to live with present materials and designs.

Coatings and finishes

- *Users still cautious about one-coat porcelain enamels and paints*
- *Lower firing porcelain enamels are accelerating use of cold rolled steel*
- *Big trend to acrylic paints*
- *Color matching is still a big problem*
- *More decorative effects being found for anodizing*

Porcelain enamel retains its popularity

The future of porcelain enamel on appliances is assured for many years to come, since consumers have learned to associate the coating with high quality and durability. In fact, consumers have accepted it so well that manufacturers think twice before droping it in favor of a less expensive coating that will do the job just as well. The interior of refrigerators, for example, is traditionally coated with porcelain enamel, yet there is some indication that a high quality organic coating will perform almost as well.

Firing temperatures are getting lower—The problem of warping and distortion at high firing temperature still remains an important problem in the appliance industry. Conventional porcelain enamels are fired at roughly 1550 F and it is often difficult to predict how and where warpage will occur and what tolerance problems will be created. Special fixtures to prevent warpage are expensive and bothersome.

However, the successful development of enamels that can be fired at lower temperatures—on the order of 1450 F and below—is solving many warpage problems. This is a very important development. Because of their lower firing temperature, new enamels may create new applications for parts that could not previously be enameled.

Trend toward cold rolled steel—Because of the premium price on enameling irons, designers have long sought a base metal that would provide similar properties at less cost. Mild steel tends to warp too much. However, users are finding—with some exceptions—that they can make many parts from cold rolled steel instead of enameling iron. This trend is being accelerated by the development of lower firing enamels.

One-coat enamels still have growing pains—Practically every appliance manufacturer has tried one-coat porcelain enamels on an experimental or production basis. At today's state of the art users are maintaining a hopeful but cautious attitude.

Keep in mind that a one-coat enamel has to perform many functions, from supplying good adhesion to looking pretty. Consequently, it is very difficult to build in all of the properties normally obtained in two coats. Procedures may be complex: one manufacturer experimenting with one-coat enamels uses an acid-type pickle to take off rust and provide good roughness, adds an acid dichromate to the bath to activate the surface, uses a heavier-than-normal nickel coating to obtain good adhesion, and uses treatment times a little longer than normal.

Despite all of the publicity on the subject there are few significant applications extant. Two examples are: electric range platform and a refrigerator pan.

At this stage there are still differences of opinion about the best way to use one-coat enamels. One manufacturer feels that if they prove themselves it may be necessary to coat only one side and rely on a heavy nickel coating on the hidden side for corrosion protection. But another manufacturer does not believe that the enamel on the hidden side can be eliminated; consequently he does not see much economic advantage in using a relatively expensive frit on both sides of premium enameling sheet, especially when the total thickness of the one-coat enamel approaches that of a two-coat system. He also objects to the defects created in one-coat enamels when they have to be refired for repair purposes.

Some special problems — Although porcelain enamel has excellent high temperature properties, users reportedly would like it to have lower emissivity and better reflectivity. These properties are especially needed where heat has to be retained, as in ranges. The emissivity of porcelain enamels is on the high side—about 92 to 96%. In contrast, the emissivity of some aluminum alloys is as low as 3%; unfortunately, aluminum alloys lose their strength at about 700 F. Aluminum-coated steel with an emissivity of 17% is being used, but quality of the material is not entirely satisfactory for appliances.

As with paints, special porcelain enamels had to be developed to withstand detergents. Extra care is still required on appliances used abroad where there is a tendency to use more active detergents and soaps. At this point designers are not sure how enamels will resist the new bleaches.

Looking ahead, it appears doubtful that multicolor porcelain enamels will be used for decoration on appliances. Since such coatings require extra firing steps their cost is high and warpage problems are compounded.

Organic coatings are meeting tougher requirements

Organic coatings have to meet severe requirements in appliances. Not only must they protect the base metal, but they must have an attractive appearance and pass the sharp eye of the housewife. Quite naturally, because of the large potential volume involved, producers have been active in developing new and better systems.

However, occasionally things go haywire. The introduction of strong detergents several years ago caught appliance manufacturers unaware, and it was some time before satisfactory organic coatings (and porcelain enamels) could be developed.

There seems to be more cooperation now, but even so such cleaners as Mr. Clean and Lestoil are creating problems, especially on some plastics. The same holds true for the new bleaches. They can cause havoc with paints and plastics, and appliance manufacturers are still not sure how successfully some components and finishes will resist bleach action. One washer manufacturer is taking the precaution of using a three-coat system—a double epoxy primer and an acrylic topcoat—on the inside of cabinets containing a bleach dispenser.

Epoxies and acrylics most popular—Epoxy coatings have long been popular for appliances because of their excellent adhesion, toughness, flexibility and chemical resistance. Although epoxies were once popular for both primer and topcoat, there has been a recent trend to use an epoxy ground coat with an acrylic topcoat. This appears to be the most popular combination at present. However, some manufacturers are using an alkyd-amine topcoat over an acrylic primer, or even a double acrylic system. Acrylic topcoats especially, have taken a strong hold for appliances; they offer a good combination of hardness, high gloss, cleanability, and good resistance to alkalis and other household agents.

What about water-base paints?—It is expected to be a long time before the protective and decorative properties of water-base paints match those of today's organic solvent systems. Naturally, manufacturers would like to use water-base paints because of their low fire hazard, but present systems are not satisfactory for exterior use, mainly because of their poor appearance. One manufacturer is currently using a water-base paint as a primer on interior parts where appearance is not important, but this is the exception rather than the rule.

One-coat paints not ready—Like water-base paints, one-coat paints require a lot of development before they become acceptable to appliance designers. Many systems have been tried but few have proved acceptable for ex-

terior surfaces, although they are satisfactory for unseen parts such as kick plates.

Some time ago a leading clothes dryer manufacturer switched to a one-coat system (resin unknown) and all indications were that it would perform better than the previously used two-coat system Humidity resistance of the one-coat system was fine, but unfortunately adhesion problems developed and a switch was made back to a two-coat system using an acrylic topcoat.

Use of vinyls is growing—Vinyl coatings are especially noted for their resistance to water and abrasion, and their future use hinges on applications where these special properties are needed. The use of vinyl-coated dish and silverware racks is well known. And about three years ago one manufacturer successfully introduced a dishwasher with a sheet steel tub sprayed with a polyvinyl chloride plastisol coating. Since that time coatings with even greater abrasion resistance have been developed and the future of vinyl coatings for dishwashers and similar applications seems assured.

Application techniques vary—Because of its savings in material and labor, electrostatic spraying of topcoats is rapidly becoming standard practice in the appliance industry. However, other application methods still have their place. Conventional spraying is still more satisfactory for getting into difficult areas and for touch-up. Also, flow coating of primers is valuable for building up raw, exposed edges that are potentially dangerous.

Fluidized bed coatings have a good potential for appliances. They are particularly well suited for small parts requiring heavy paint buildup. And if ways could be found to reduce cost and to apply the coatings selectively, say to only one side of a panel, they would probably have an even better future.

Most manufacturers feel that sufficient corrosion protection is obtained by applying paints directly over steel that has been given a phosphate conversion coating. However, one manufacturer questions the protectiveness of this system in extreme environments. In such cases he feels that best results are obtained by using zinc-coated base metal. Thus, if the paint is damaged the zinc will still provide good corrosion protection. The sheet used is bought precoated; all other parts are zinc electroplated.

Color matching remains troublesome

An appliance often contains many elements—paint, porcelain enamel and plastics—that are all required to look alike. And the color matching problem can be a real headache. One washing machine manufacturer, for example, reports that he has to specify four different shades of white for his cabinet, door, knobs and plastics surface panel to get a good color match.

Following is a summary of some of the troubles that crop up. Naturally manufacturers are exerting constant pressure on raw materials suppliers for more stable materials. However, it is doubtful if the matching problem will ever be completely solved.

1. Some colors exhibit different shades of white in daylight and artificial light.

2. Some exterior oven paints and plastics knobs still tend to yellow after aging and exposure to heat and grease. The same problem is encountered with white and light colored porcelain enamels for oven interiors. However, both consumers and manufacturers still seem to prefer enamels with spattered effects which hide dirt and manufacturing sins.

3. Available porcelain enamel colors sometimes dictate the color that has to be used for paint and plastics.

More applications for anodizing

As with the automotive industry, the appliance industry is making widespread use of anodized parts (see also earlier section on decorative trim). However, users find that considerable care is required during processing, particularly with coloring. They report trouble with blues and greens which tend to fade when exposed to ultraviolet light. Also, it is difficult to obtain a good dark, matte color or a light color with high gloss.

Best color is being obtained with mineral dyes. Vegetable dyes sometimes cause trouble. Color matching is also a problem. It is affected by the aluminum alloy used and by the time and temperature of treatment. At this stage of use it is difficult to see how the color matching problem will be licked, and users are relying largely on cut-and-try approaches.

Vacuum metallized coatings popular for their low cost

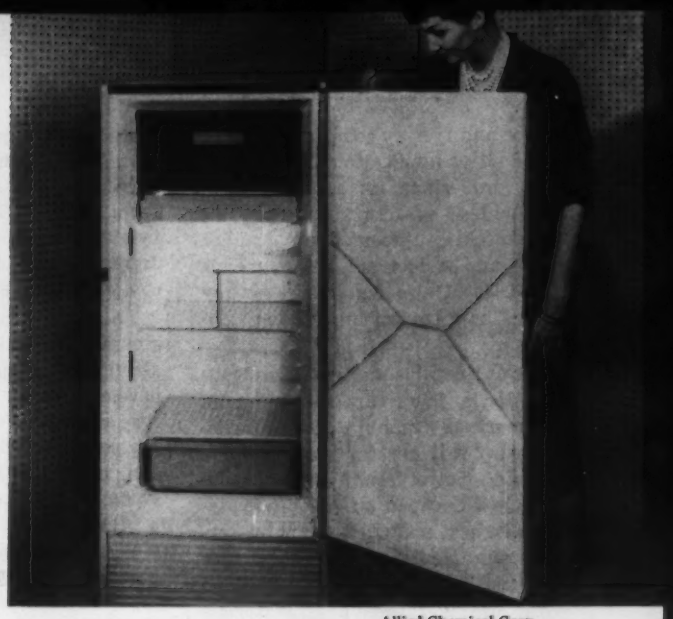
As in other industries, appliance designers are constantly looking for an inexpensive finish with a metallic look. And, with some exceptions, vacuum metallized coatings appear to fill the bill, although they are not as durable as solid metal or electroplated parts.

One manufacturer reports good results with first surface (outside surface) vacuum metallizing on decorative trim such as knobs. Another user asserts that such first surface coatings are not satisfactory since the thin layer of metal and its protective coating can be easily damaged or worn away. Of course, this is not a problem with parts that are coated on the second surface (reverse side) where they cannot be damaged. Nevertheless, one user does very little vacuum metallizing because he feels that its quality is relatively low and not in keeping with the premium materials used in the rest of his appliance.

Some users are dissatisfied with the durability of the protective organic coatings used over metallized coatings. They report that coatings tend to yellow and lose their appearance, and are affected by heat and grease. More applications would probably develop if a more heat resistant protective coating were developed, and if the metal coating could be produced with better appearance on large, flat surfaces.

Owens-Corning Fiberglas Corp.

Glass fiber *is still most popular insulation for ranges and other high temperature uses.*



Allied Chemical Corp.

Urethane foams *are starting to replace glass fiber insulations for refrigerators. Trim and door liner have been removed from this unit to show foam's ability to fill voids.*

Thermal insulation materials

- *Glass fiber still best at high temperatures*
- *Foams growing in popularity for refrigerators and freezers*

Glass fiber fine for high temperatures

Ever since it replaced mineral insulations many years ago, glass fiber has remained the undisputed king of high temperature insulations for appliances. In addition to its important advantage of low cost, the material has low thermal conductivity and high tensile strength, is odorless, and resists moisture, fire, rotting, and fungi and bacteria growth. Although some grades are usable to 2000 F the bonded grades usually specified for appliances have a maximum limit of 600 F.

Probably the biggest objection to glass fiber is its high bulk. As one user put it, "We would like to have a high temperature insulation that has the same price as glass fiber, yet is one-half as thick and has five times better thermal efficiency." It is doubtful whether this goal will be attained in the near future. Better insulations have been developed for other high temperature uses, but they have to be ruled out for appliances because of their high cost.

High temperature foams, of course, have been investigated for appliances. But they are costly and just cannot take the high temperatures involved. A normal oven runs all the way from 140 to 550 F; if the broiler is used temperature may go over 650 F.

Foams will probably win out at low temperatures

Bonded glass fiber is still an eminently popular insulation for today's refrigerators and freezers. However, most manufacturers now feel that it will gradually be replaced by foam systems that occupy less volume and have lower thermal conductivity.

One manufacturer has solved some of the problems associated with glass fiber by placing mats of the material in a laminated plastic and paper bag and replacing the air in the bag with a fluorocarbon refrigerant (see Gas and Fiber Insulations Cut Refrigerator Wall Thickness By 50%, M/DE, May '60, p 142). Dramatic space savings and better thermal properties have been obtained. However, this system is relatively costly and has created production problems. Eventually, it may be replaced by a foam system.

Polystyrene popular for preformed shapes

The biggest breakthrough in the use of foams for refrigerators and freezers occurred several years ago with the development of rigid, prefoamed polystyrene insulations. Although once widely hailed, they have been supplanted to a large extent by better materials.

Users report that the biggest disadvantages of polystyrene foam are its friability, relatively high cost, inability to be foamed in place, and susceptibility to damage by solvents. Despite these shortcomings, it is still being used on the top of refrigerator evaporators and between refriger-

ator and freezer compartments. In the latter application the material is ideal since its good strength provides structural support (something glass fibers cannot do) and it does not absorb moisture. It is also being successfully used as a trough in air conditioners.

Considerable interest was generated a few years ago when an important manufacturer developed a refrigerator made up of a rigid polystyrene foam sandwiched between an inner polystyrene sheet and an outer polyester-impregnated glass cloth sheet (see "Plastics Foam Sandwich Used for Refrigerator Walls," *Materials & Methods*, May '57, p 150). Although it operated successfully, the unit was not something you could quickly run down an assembly line. Production was slow because of the time consumed in bending and sealing joints, and because of tolerance and misalignment problems. Also, the foam had to be cut to shape and there was too much scrap.

Foams made from polystyrene beads appear to be more useful for appliances. Not only can they be premolded to shape but their density can be closely controlled. They are not suitable for foaming in place because of their poor adhesion to metal and inability to produce a tight joint. Nevertheless, they are quite useful for structural insulation parts that can be prefoamed and later installed. Some care is required as they are affected by solvents.

Big trend to urethane foams

In a relatively short time urethane foams have gained rapid acceptance for refrigerator insulations. One of the country's leading gas refrigerator manufacturers will introduce an all-urethane foam insulation this year, and other manufacturers are inaugurating similar systems.

Early systems—Just a few years ago manufacturers were ruling out castor oil-base urethane foams because of their odor and relatively poor thermal conductivity. Hopes were ignited when polyester urethane foams blown with carbon dioxide were introduced. These foams could be foamed in place and had better insulation properties than polystyrene foams, but still were not completely satisfactory.

The breakthrough—The most significant breakthrough occurred about two years ago with the development of Freon-type blowing agents to expand the foam. By using such agents, designers can now get k values roughly twice as good as anything before.

Most of the original development with these blowing agents was done with polyester-type urethane, but there is a trend now to use polyether-type urethanes.

Problems to be solved—Although urethane insulations are successful, many problems remain to be solved. Although the foams have an initial k value of 0.1 to 0.11, values can rise to 0.14 and above (in an open cut sample) with time. In addition, materials producers are trying to reduce thermal degradation and provide better foaming qualities, such as flow around corners and void-filling ability.

There is no question but that urethane foams are relatively expensive. For example, urethane currently used costs $1.30 per cu ft, as compared to 90¢ per cu ft for pre-foamed polystyrene and 76¢ per cu ft for styrene beads. However, prices are falling rapidly. And as the public accepts this insulation it is expected that increased demand will make the urethanes competitive.

A big cost drop can also be expected if one-shot foam systems can be developed. At present, manufacture of prepolymers adds an extra 5 to 10¢ per lb to materials cost. Also, there is lots of room for improved machines that will automatically place the foam in the mold.

Another deterrent to greater use of urethanes is the Underwriters' requirement that the materials be self-extinguishing and not contribute to general flame spread in case of fire. This requirement has created great difficulties for suppliers in providing materials that have good k values, yet are self-extinguishing.

Finally, the use of a Freon-type blowing agent has been found to seriously affect polystyrene refrigerator parts, such as door liners. Thus, designers may have to substitute an ABS material for polystyrene. One manufacturer estimates that this may increase his door liner cost by 50%.

How polyurethane foam is being used—As mentioned earlier, urethane foam insulations will really come into their own this year. One refrigerator manufacturer has three production foam lines—for the door, the absorption unit, and the cabinet itself. All insulation is foamed in place except for the door which uses a dummy metal mold in place of the regular polystyrene liner. This mold has to be used in production since the foam tends to craze the polystyrene liner. (An incidental problem: it is difficult to get a good mold release for parts that have to be molded in place.)

And after urethane foams?—The epoxies appear to hold much promise for future foam insulations. In addition to excellent thermal properties, epoxy foams have excellent stability and structural properties. However, many problems remain to be solved. Automatic mixing is a problem because of tight composition limits, exothermic curing is also critical, and the materials have an undesirable odor.

Silica aerogel has caused problems

Although it has very low thermal conductivity, fine silica aerogel bead insulation has not proved successful for refrigerators, mainly because of production problems. The beads have to be blown to get them into insulation compartments and, once in, they tend to leak out of any openings. Also, the beads tend to shake down with vibration and occupy less than their original volume. Finally, they create a servicing problem since they tend to run out if the evaporator has to be removed for servicing.

Materials for cooling and heating

- *New materials are key to efficient thermoelectric appliances*
- *Current electrical resistance alloys good, but some problems remain*

Better thermoelectric materials needed

Widespread use of appliances based on thermoelectric principles and materials is not generally foreseen before the mid-1960's. Right now materials are the main stumbling block and much development is required.

Properties needed — Thermoelectric materials for cooling and refrigeration applications must have a high Seebeck coefficient (S), low electrical resistivity (ρ), and low thermal conductivity (k). The relationship of these properties can be expressed by a figure of merit: $Z=S^2/k\rho$; the higher the value, the better the material.

At present figures of merit are ranging from 0.0025 to 0.003, and in some cases as high as 0.004. Designers feel that in order for the materials to produce cooling efficiencies as good as today's devices, figures of merit of 0.013 to 0.016 will be required.

Available materials—Keep in mind that the following applies to materials for cooling applications, not power generation. (See p 134 in this issue.)

The most favorable material at present appears to be bismuth telluride. There is a possibility that better materials may be developed. If so, designers feel that they will be semiconductors or semi-metals.

As presently used (see accompanying photo) a bismuth telluride slug is inserted between fins of copper and aluminum. It does not make much difference which metal is used on the cooling side; both have good electrical and thermal conductivity. Actually, final choice of materials depends on the application, and copper is used where cost is not too important.

Potential applications—There is a natural tendency to think of thermoelectric cooling devices as a replacement for present appliances. However, designers feel that the devices will have their greatest impact in making possible new and different products for cooling. Aside from military products, one of the largest devices constructed to date is an experimental 2.3 cu ft refrigerator.

Status of electrical resistance alloys

Outside of high cost, appliance designers report little difficulty with electrical resistance alloys such as the commonly-used nickel-chromium alloys. One manufacturer reportedly had a problem some time ago when the elements on each side of a toaster had different emissivities, thereby causing uneven toasting. He discovered this problem occurred only with toasters containing elements from different suppliers. This problem was licked by keeping the batches separate and using elements from the same batch in a given unit.

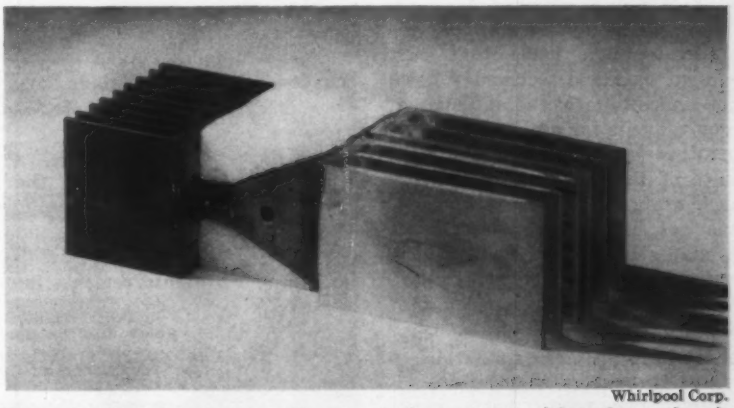
Promise is held for new aluminum - chromium - iron alloys now under development for resistance heating. (See p 10 in this issue.) These alloys are reported to combine low cost with high resistivity and good oxidation resistance up to 2200 F.

Users are predicting that circular range elements will one day be solid, flat disks, rather than spiral as at present. It is expected that they will consist of a heating element embedded in metal. However, development has been stymied by the need for a low cost embedment metal that does not warp at 800 or 900 F. This material must also have high corrosion resistance, low specific heat and high thermal conductivity.

If it were not for its poor strength at high temperature, aluminum would appear to meet these requirements. No other material presently appears suitable.

Acknowledgment

The author is indebted to designers and engineers from the following companies for their unstinting cooperation in providing information for this article: Caloric Appliance Corp., Hotpoint Co., Maytag Co., Westinghouse Electric Corp., and Whirlpool Corp.



Whirlpool Corp.

***Bismuth telluride** is presently one of the most promising thermoelectric materials. Round slug of material is used between copper and aluminum fin assembly. Whole series of such assemblies cool experimental 2.3-cu ft refrigerator (right).*

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High Temperature Plastics: *Where Do We Stand?*

A timely assessment of our progress in developing organic, semi-organic and inorganic polymers for long-time service at 500 F and above.

by Dr. W. Brenner, *Senior Research Scientist, New York University*

■ Research and development efforts in improving thermal stability of plastics have been aimed at solving two distinct problems in high temperature environments: short-time exposure of several seconds or minutes, and long-time exposure of several hundred hours. The first problem has been solved, for the most part. The second problem is much tougher, and although great efforts have been made, relatively few concrete results have been obtained.

An increasingly strong body of expert opinion holds that our present chemical technology does not suffice to meet the anticipated requirements for usable high temperature polymer systems. In spite of the money available for such work, the present technology has not been highly successful. A major breakthrough in chemical science and technology may well be necessary to meet the presently established goals.

Short-time problems: ablation seems to be a good solution

Short-time requirements have been dramatized by the nose cone problem in missiles, and the "thermal barrier" in high speed aircraft. Here substantial progress has been made by the utilization of the ablation principle. The high heat absorbing capacities and good thermal insulating properties of plastics provide excellent short-time thermal protection. They also offer significant weight savings over competitive ceramic-based systems.

Surprisingly enough, the use of plastics for such short-time high-temperature environments has involved little research on new types of polymeric materials. Present achievements have been obtained with known types of plastics, although certain modifications have been made to improve behavior for specific applications.

The most widely used plastics for such applications are the phenolics and phenyl silanes, e.g., 37-9X produced by CTL, Inc., and SC 1013 produced by Monsanto Chemical Co. Reinforcements include conventional glass fibers, and 96% silica glass fibers, as well as asbestos, nylon, and the newer graphite textiles.

Long-time problem: much more remains to be done

Most of the research and development studies of radically new polymeric materials have been aimed at obtaining long-term thermal stability. But thermal stability is used only as a primary screening requirement for various candidate materials; alone it is not enough to qualify a proposed material for further studies. In addition a material must have at least the potential of suitable physical strength properties at both room and elevated temperatures; it must be chemically inert to the anticipated environments; and, most important, it must be capable of being fabricated into useful end products by, if possible, standard processing methods.

At present, the long-time thermal capabilities of the best commercially available plastics are in the 500-550 F range; 600-800 F for intermittent service. As the bar chart shows, the outstanding performers are organics such as fluorocarbons, phenolics and epoxies, and the semiorganic silicones. The temperature limits shown for these materials are maximum temperatures for long-time service.

Research on plastics materials with substantially improved thermal stability has taken two directions: 1) chemically modifying existing polymers by introducing more thermally stable groups and/or molecules, such as fluorine, and 2) synthesizing entirely novel polymeric structures.

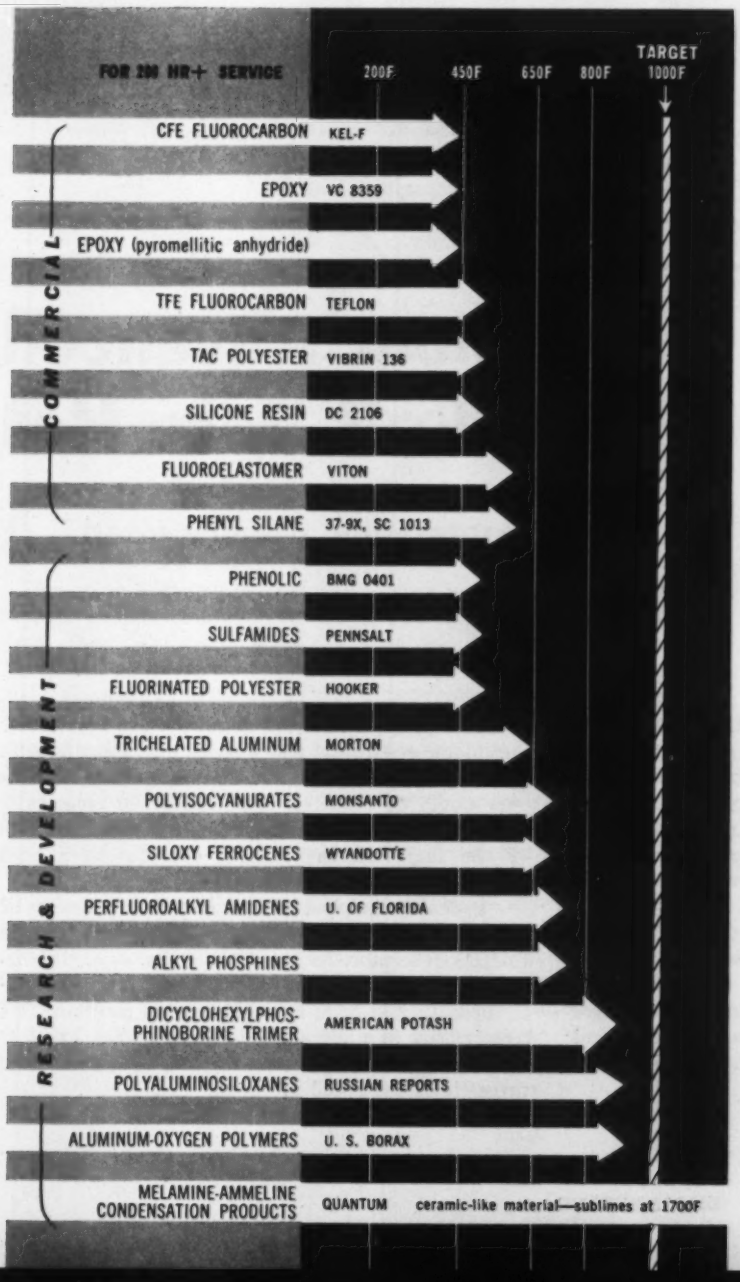
Organic polymers reach for 500-700 F range

Fluorinated polymers continue to be widely studied. Elastomers based on fluorinated acrylate esters, thermally stable at temperatures above 400 F, have been prepared by Hooker Chemical Co. Fluorinated acrylic acid esters have been studied by Minnesota Mining & Mfg. Co. Hooker has

also prepared fluorinated glycols for use in polyester resins. After aging at 500 F, fluorinated polyester laminates lose only about 10-15% of their initial high temperature flexural strength, as opposed to losses of as much as 70% by laminates made with hydrocarbon glycol polyesters.

Polyisocyanurate and related polymer structures have been investigated by Monsanto Chemical Co. In several cases macromolecules, or polymers, have been obtained with limited thermal stability at temperatures as high as 700 F. But laminates made with these polymers have been low in strength and have shown other deficiencies as well.

One of the more interesting monomers is perfluoroglutaronitrile, synthesized by Hooker and others. It is used to synthesize fluoroamidine polymers. Dr. H. C. Brown and his coworkers at the University of Florida have developed several perfluoroalkyl amidine polymers with thermal stability up to 750 F, as well as resistance to strong, oxidizing mineral acids at elevated temperatures. A promising elastomeric copolymer has also been prepared from perfluoroalkylimidine and perfluorobutyramidine.



Inorganic polymers show some promise as high as 700-900 F

Although the term "inorganic polymers" has been widely used, investigations have involved so many different types of polymeric structures that whether a material is inorganic, organic or semi-organic depends only on the viewpoint taken. For example, work in metal-containing polymers is primarily based on the framing of an inorganic molecular backbone with organic substituent groups.

Boron—Although much of the initial glamour of boron polymers has worn off, there is still considerable interest. Several alkyl phosphines have shown thermal stability up to 750 F. American Potash & Chemical Corp. has reported a dicyclohexylphosphinoborine trimer stable at 900 F. However, no usable polymer has resulted as yet.

Aluminum—Aluminum-containing polymers are of great interest now, particularly since their mention in recent Russian publications. Andrianov and his coworkers have extensively investigated the macromolecular structures now known as the polyaluminosiloxanes, some of which have shown stability at 900 F. Such polymers are actually part of a more general class of polymer compounds known as polymetal siloxanes.

American work in this field has been carried out by such organizations as U. S. Borax and Chemical Co., Hughes Aircraft Co., Ethyl Corp., and others. U. S. Borax has developed inorganic polymers based on alternating aluminum and oxygen atoms on the polymer backbone; these have shown thermal stability approaching 900 F. Morton Chemical Co. and B. F. Goodrich Chemical Co. have studied aluminum chelate polymer possibilities. Morton has studied trichelated aluminum polymers with stabilities up to 650 F.

Intractability, or poor workability, has been one of the basic

problems with aluminum-containing polymers, probably due to extensive crosslinking. American efforts to overcome this problem have not been too successful.

Tin—Although under study at the University of Pennsylvania and Ethyl Corp., tin-containing polymers, such as the stannosiloxanes prepared by Dr. Koenig, have not appeared too promising. Alkyl tin methacrylate polymers stable up to 400 F have been synthetized by the Quartermaster Research and Development Command. The possibility of using tin hydrides in preparing organotin polymers is being investigated by the Institute of Organic Chemistry in Holland.

Silicon — Research on silicon-containing polymers is continuing. Hughes Aircraft has studied the preparation of poly (trimethylsiloxy) metalloxane polymers. General Electric Co. is investigating borosiloxanes, but results have not been encouraging. Phenyl silicones have been studied by General Electric, Dow Corning, Linde and Midwest Research Institute. Wyandotte Chemicals Corp. has looked at siloxy-ferrocenes, some of which are stable up to 700 F. As yet no substantial improvements in thermal stability over present silicones have been achieved.

Other developments in brief

Innumerable other attempts are being made to develop high-temperature-stable polymers—organic, semi-organic and inorganic.

▸ Quantum, Inc., has studied phosphorus pentoxide condensation products with melamine and ammeline materials and has produced ceramic-like materials subliming at about 1700 F.

▸ Polyphosphoryldimethylamides are being researched by Monsanto.

▸ Sulfur-nitrogen type polymers are being studied by Pennsalt Chemical Corp. Pennsalt polymers based on sulfamide generally have thermal stabilities below 500 F.

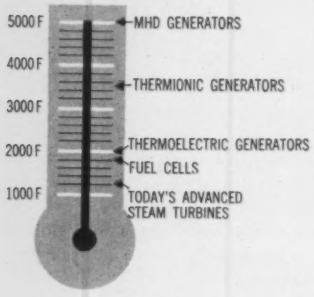
▸ Polymers produced by the decomposition of ammonium diuranate have been investigated by National Lead Co.

▸ Dr. Hazeldine has developed some novel fluorine-containing elastomeric structures in England, but their thermal stability has not been outstanding.

▸ Linear polymers with a triazine nucleus and stable up to 750 F have been developed by Wright Air Development Div. in "in house" work.

▸ Phosphonitrilic chloride and fluoride polymers have been known for many years; principal handicap is their hydrolytic instability. Work in this country has not been successful in overcoming this difficulty. Substantial progress is claimed for work being done in England.

THE HIGH TEMPERATURE PROBLEM



Four Advanced Pose Hot

by the Editors, *Materials in Design Engineering*

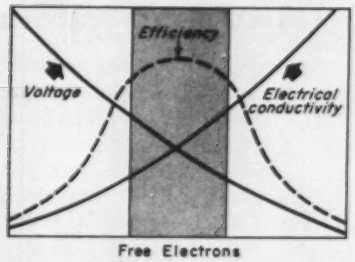
Four new direct power generating systems recently described by Westinghouse Electric Corp. show great promise. Because these systems operate at high temperatures their ultimate success hinges on the development of new and better materials.

One of the four—the fuel cell—can operate over a wide temperature range, even down to room temperature. But for central power station use the system appears to be most efficient at 1800 F. This temperature creates many materials problems.

Thermoelectric power stations, also, are still a long way off. Thermoelectric materials must have higher efficiencies than those obtainable today, and they must be able to perform at an operating temperature of 2000 F.

Still greater materials problems are created by thermionic generators which operate at about 3500 F. At today's state of the art, 10,000 sq ft of cathode area would be required to generate 100 megawatts at 3500 F. This requirement is further complicated by the fact that the cathode operates in a high vacuum over its entire area.

Probably the most serious materials problems of all will be encountered in the magnetohydrodynamic (MHD) generator. As projected by Dr. J. A. Hutcheson of Westinghouse, a 100-megawatt MHD generator operating at 5000 F would have to maintain this temperature in a space 3 ft in cross section by 60 ft long. The gas would move in this space at about three times the speed of sound.



1—Maximum efficiency of thermoelectric materials is a compromise value between high voltage and high conductivity.

***Practical demonstration** of 100-w thermoelectric generator using propane gas as a fuel. Future generators are expected to be much larger and may be used in nuclear generating stations and ship propulsion plants.*

Power Generators Materials Problems

1. Thermoelectric generators

The basic principle of thermoelectric power generators stems from the discovery almost 150 years ago by the German physicist Thomas Seebeck that the flow of heat through a metal segment could produce a voltage difference between its hot and cold ends. Application of the principle has been limited because of the low voltage and power outputs. However, quite recently the development of new thermoelectric materials has permitted a rise in power output and efficiency to levels suitable for electric power generation.

A key factor in the growth of thermoelectricity is the ability of designers to adjust the free electrons in semiconductor materials. Two basic relationships are involved. First, the output voltage of any thermoelectric material is *inversely* proportional to its number of free electrons. Second, the conductivity of a material is *directly* proportional to its number of free electrons.

Therefore, to obtain maximum power output and efficiency the electron density of a material must be adjusted for a compromise value between high voltage and high electrical conductivity. Fig 1 demonstrates an effective compromise. Optimum efficiency is reached at an electron density of about 10^{19} free electrons per cu cm, a value well within the range of good-conductivity semiconductors and one that affords Seebeck voltages of about 97 μv per deg F.

It appears that in about five years new thermoelectric materials will have an inherent efficiency of about 30%. A major breakthrough in materials will be necessary to produce greater efficiency. Nevertheless, 30% efficiency is suitable for many important applications for thermoelectric generators operating in the 1000-kw range.

Many materials ruled out

Some typical materials that demonstrate acceptable efficiency for thermoelectric generators are zinc antimony, lead telluride, bismuth telluride and germanium telluride. For practical purposes it is desirable to combine different thermoelectric materials, since each material has an optimum operating temperature range. For example, several semiconductor materials are satisfactory for low temperatures, on the order of 1100 F. However, these materials are not suitable at higher temperatures—in the 1800 F range.

Another problem associated with thermoelectric materials is that they must be joined so that contact resistance is low. Also, above 570 F it is necessary to shield the materials from air to prevent corrosion of materials and joints.

Modified insulator materials

Obviously, materials are needed that are free of this behavior at higher temperatures. A promising step suggested by Dr. Zener of Westinghouse is the use of insulator materials modified to make them good thermoelectric materials. This approach appears promising, as there are many insulators that do not become intrinsic conductors in the 1800 F range. Pure nickel oxide, for example, is normally an insulator, but when it is modified with 3% lithium its resistivity decreases to about 0.01 ohm-cm. This approach has recently resulted in a new mixed valence material, samarium sulfide, which has good properties as high as 2000 F.

2. Magnetohydrodynamic (MHD) generators

About 130 years ago Michael Faraday discovered that a conductor moving in a magnetic field generated an electric current. This principle is widely used in conventional electric power systems. However, Faraday's experiments showed that power could also be generated by a flowing liquid metal in a magnetic field. Today's MHD power generators stem from this principle.

In present MHD designs, hot ionized gas travels through a magnetic field applied at right angles to the flow, and past electrodes in contact with the gas stream (Fig 2). Electrons in the gas are deflected by the field and, after colliding with other particles in the gas, head diagonally to one of the electrodes. An electric current is produced as the electrons move from the anode, through the load, to the cathode, and back again to the gas stream.

Why New Methods of Power Generation?

The need for new methods of power generation is inescapable. Man is now facing the fact that his natural fuel resources are depleting rapidly, and that many conventional methods of generating power are cumbersome, complex and inefficient. Leading equipment manufacturers are taking a new look at basic scientific principles that have been known for many years to find how they can be used to meet future power needs.

The motivation force behind the quest for new power generation systems has been aptly stated by Dr. S. W. Herwald, vice president–research, Westinghouse Electric Corp.: "Whether one takes the optimistic estimates (of our resources) or the pessimistic ones, you reach the conclusion that almost certainly within the next century the supply of energy from conventional fuels, which now account for some 95% of our needs, will be inadequate. Growing numbers of technical people are convinced that the question is not whether we *shall* reach this state of affairs, but *when*. Coupled with the quest for new prime energy sources—fission, fusion, solar power—is the conviction that we must begin now to look for new ways to more efficiently exploit the diminishing fuel supply at our command.

"Second, there is the conquest of space. In the excitement surrounding the development of propulsion systems for launching ever-larger and more complex space vehicles, one is likely to overlook the vital need for adequate power for man in space once he gets there. Without it, he is helpless; with it, he can exist under almost any conditions.

"Small, reliable, self-contained electric power plants are a space essential. And here on earth—particularly in those remote areas which cannot be served with power quite so effectively by any other means, and particularly for applications of military interest—they will find increasing usefulness."

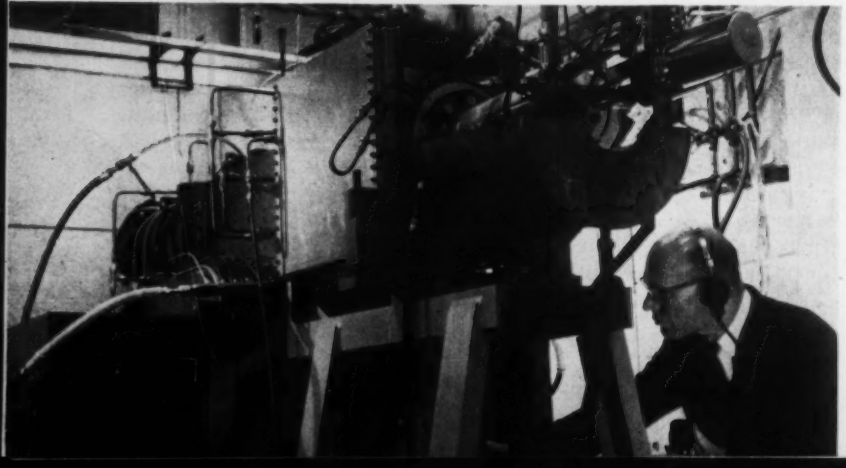
Few materials can meet the operating temperatures

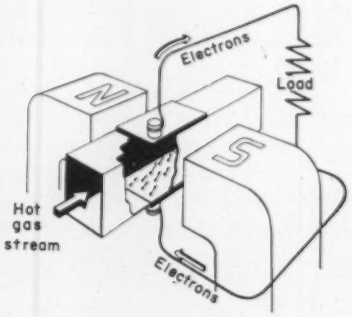
The most direct way to obtain a conductive gas is to partially ionize it by heating. However, the temperatures that would be required are beyond the limits of even the most modern materials.

"Comparatively low" operating temperatures—about 4000 to 5000 F—can be used if the gas is "seeded" with a material such as potassium or cesium to promote conductivity. Nevertheless, Westinghouse's Dr. Stewart Way says, "The possibility of MHD generation, as currently conceived, hinges on the small region of overlap between the temperatures that a few materials are able to tolerate, and the temperatures which are necessary, even with seeding, to obtain adequate conductivity."

Dr. Way says further, "Materials must be developed to better withstand high temperatures, sudden temperature changes, and chemical interaction with the alkali metal seeding materials. New engineering and design approaches must be found to build durable parts of ceramic, which have been conventionally made of metal. Durable electrodes must be developed to withstand high temperatures and chemical attack, and yet they must be good conductors."

Experimental MHD generator *has been tested at 2½ kw and is designed to produce 10 kw. Future units are expected to operate above 100,000 kw.*





2—*Operating principle of magnetohydrodynamic (MHD) power generator.*

3. Fuel cells

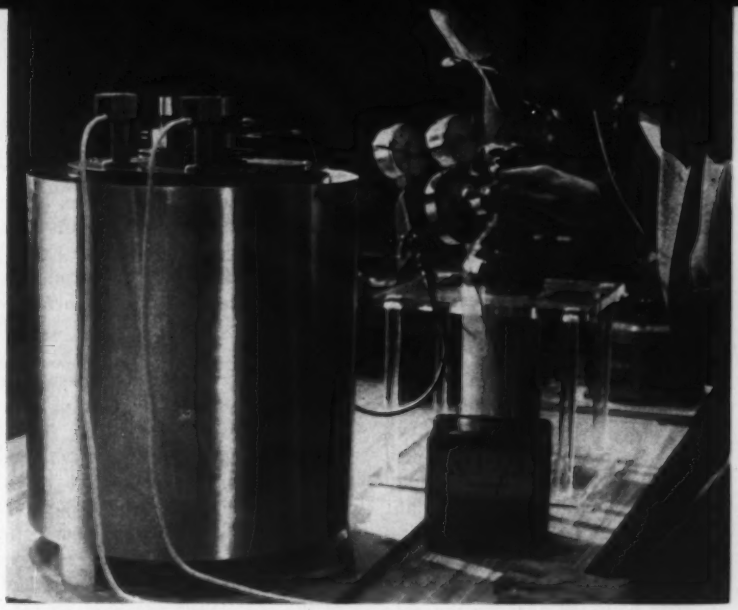
A fuel cell is an electrochemical device that converts the free energy of a chemical reaction directly to electrical energy. In contrast to conventional batteries, the fuel is low cost and the oxidant is fed into the system continuously.

Fig 3 shows a very simple cell called an oxygen concentration cell. It consists of an electrolyte that is an insulator to electrons but conducts an electric charge in the form of oxygen ions. The electrolyte is sandwiched between two electrodes. When the oxygen concentrations at the two electrodes differ a voltage is created across the electrode-electrolyte sandwich.

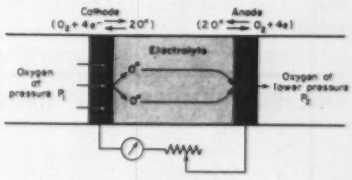
High operating temperatures needed for fossil fuels

A wide variety of fuel cells have been developed to date. However, all fuel cells operating below 480 F can use only hydrogen or other expensive fuels. One way to reduce cost is to use inexpensive fossil fuels in fuel cells operating at high temperatures — on the order of 930 F.

The high temperatures required for fossil fuels create severe materials requirements. In addition to being inexpensive, cell materials must be highly resistant to corrosion for long periods at high temperatures and still retain useful conductivity. Consequently, considerable research is needed on the physical and chemical properties of fused salts, special ceramics and metal alloys that will satisfy critical high temperature requirements. Also, fuel processing must be studied to obtain maximum efficiency and to prevent undesirable side reactions such as carbon deposition at fuel inlets.



Experimental fuel cell *in furnace contains carbon fuel and oxygen or air which react electrochemically in the presence of heat to produce electrical energy.*



3*—Operating principle of fuel cell of a very simple type.*

4. Thermionic generators

Thermionic generators produce electrical power by using the electrons are emitted into a vacuum of a material when it is heated. Unlike thermoelectric generators they differ in that the heated electrons are emitted into a vacuum rather than a solid. Thermionic generators must operate at high temperatures in order to produce a high potential difference between the interior and exterior of the emitting material (a quantity →

Experimental thermionic tube *contains a glowing wire which emits electrons when heated, causing current to flow in ionized cesium gas.*

known as work function).

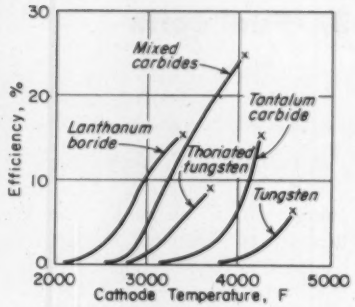
An important factor inhibiting current flow is a phenomenon called space charge—the mutual repulsion of electrons. Its effect can be eliminated by introducing heavy positive metal ions, such as cesium ions.

Many materials problems have to be solved

According to Westinghouse's John Coltman, "The efficiency of conversion (heat to electricity) depends on such material properties as work function, electron emission constants and radiant emissivity, and on operating temperature. The operating temperature is, in turn, limited by the melting point or evaporation rate of the cathode. Thus, materials properties, both of the anode and cathode, are important in deciding if an efficient arrangement is possible."

Fig 4 shows some calculated efficiencies for a variety of possible cathode materials as a function of cathode temperature. Note that each material dictates a certain operating temperature and that many materials, unfortunately, reach excessive evaporation rates before they develop useful efficiencies.

Summarizing the materials problems still to be solved, Mr. Coltman further states that, "Whether it (thermionic conversion) becomes competitive with other means will depend largely on the solution of problems concerning the properties of materials. It should be pointed out that in the past there has been no particular urge to find or produce materials having the peculiar properties demanded by the thermionic converter. The field is therefore one which is largely unexplored and in which one may expect to see advances of considerable magnitude."



4—Efficiency of proposed thermionic materials. Calculations assume an effective emissivity of 0.5 and an anode work function of 1.8 v. Upper portion of each curve terminates at point where cathode evaporation becomes high enough to evaporate 4 mils of material from the cathode in 1000 hr—a condition assumed to represent useful life.

THE HIGH TEMPERATURE PROBLEM

Needed: Textiles for the Space Age

by J. H. Ross, *Chief, Functional Textiles Section, Wright Air Development Center*

High temperatures, *such as those encountered in deceleration chutes after re-entry, are one of the most critical textile problems.*

■ Textiles are probably the most commonly overlooked material required for the "space age." Yet, before we can launch—and subsequently recover intact—a manned space vehicle, textiles must be available to meet the following requirements:

1. Fibers that retain 75% of their strength when exposed at 1500 F for as long as 10 min, and at 1200 F for 10 to 20 min.

2. Fibers that retain 80% of their strength after continuous or intermittent exposure (totaling 4×10^7 Langleys) to solar or electromagnetic radiation. (Solar radiation most likely becomes in-

creasingly severe as atmospheric dusts are left behind.)

3. Parachute textiles that have a high degree of flex and excellent recovery from long term compressive creasing (150-250 psi) caused by pressure packing.

4. Textiles that withstand exposure to ozone (11 ppm at 100,000 ft); to ionized gases (10^5-10^6 ions per cu cm at 300,000 to 1,000,000 ft); and to solid particles that may cause corrosion of metal fibers or chemical decomposition of ceramic and organic fibers.

5. Coated fabrics having no vapor permeability as well as resistance to exotic fuels and chemicals.

These are new and tough requirements for textiles. This article summarizes briefly the present status of textile materials for space use, and indicates the most pressing areas of research and development.

Textile fibers:
a high temperature problem

Heat resistance is probably the toughest of the requirements for textiles to meet. The accompanying curves show stagnation temperatures at given Mach numbers and altitudes as calculated by the Air Force for a parachute leading edge. None of the presently available organic fibers offer good strength at temperatures above 500 F. Results of an initial screening study, shown in the accompanying table, indicate that organic fibers can be protected from aerodynamic heating to some degree by chemical coatings. But much work is yet to be done before substantial increases in heat resistance can be obtained by this method.

Inorganic textile fibers, of course, appear to offer the best solution to the high temperature problem. Glass fabric with a TFE-fluorocarbon coating has good strength retention at 650 F. Other types of ceramic fibers, either uncoated or partially coated, would provide the required heat resistance, but fiber-on-fiber abrasion and poor flex life must be overcome before they can be used successfully.

EFFECTS OF COATING NYLON RIBBON
(AF Wind Tunnel; Stagnation Temperature, 900 F)

Coating	Method of Application	Coating Weight, gm/in.	Sample Life to Total Failure, sec	Remarks
None	—	—	0.36	—
Hexachloroethane	Deposited from a solution in CCl_4	0.90	0.92	Coating tends to blow off sample
Chloroanthraquinone	Pressed with hot plates into the ribbon	0.64	2.1	Coating seems to have good mechanical stability
Stainless Mesh	Mesh doubled with leading edge folded	0.00	3.60	Stainless steel extended into the grips
Hexachloroethane	Deposited from a solution in CCl_4; covered with stainless steel mesh	2.42	3.88	Stainless steel did not extend into the grips

*Nylon ribbon 2 in. wide, 100-lb breaking strength; air density equivalent to 100,000 ft; tunnel velocity, Mach 5.

Fibers and yarns of high temperature metals or superalloys are becoming available. Probably the most heat resistant alloy being studied is René 41; others include types 304 and 316 stainless steel, Hastelloys, and Udimet alloys. Pure molybdenum and tungsten are good potential fiber materials if adequately protected from high temperature oxidation.

The most important area of study for these metallic fibers is the development of filaments with diameters of 0.0005 in. and finer, and determination of structural properties of multifilament yarns made by plying two or more such filaments.

The major shortcomings of metallic fiber textiles at present are high weight, low tear strength, high porosity and lack of fabrication or joining techniques.

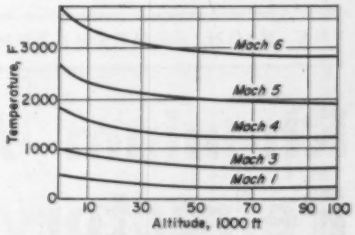
Future work—In inorganic fiber development, particular emphasis must be applied to:

1. Research in filament drawing techniques, weaving, and determination of physical properties vs temperature.

2. Development of thin, nonporous, high temperature protective coatings for refractory metal fibers, and abrasion resistant, flexible coatings for ceramic fibers.

3. Study of oxidation rates of fine metal fibers.

4. Determination of emissivity of inorganic fibers.



***Stagnation temperatures** for parachute leading edges.*

Also, little is known about effects of the unique space environment on either organic or inorganic textile fibers. For example, studies must be made of the effects on textile fibers of complete vacuum, disassociated gases, ionized gases, ozone, unfiltered solar radiation, high speed solid particles, and electromagnetic radiation.

Designing the textile

Fiber development problems cannot be disassociated from textile or fabrication problems. The behavior of the textile structure made from newer fibers must be understood; the woven fabric is useless unless it can be fabricated or joined to form a usable device.

One of the most important problems is developing efficient seaming methods. Even nylon in high speed parachutes is difficult to join effectively without creating a bulky, stiff, sometimes inefficient seam. Seam efficiencies

above 70-75% are difficult to achieve without producing a hard-to-handle structure. The problem will be compounded in the stiffer, less crease resistant, inorganic fiber textiles.

During reentry two conditions may be met by deceleration devices. The first is low drag resulting from the low density atmosphere encountered during the initial reentry stages. The fabric should have low porosity and low strength. The second condition is high drag, encountered where chute deployment is delayed until air density is high. In this case, fabrics must be extremely strong and of controlled porosity.

Consequently, the effect of changing atmospheric density on air flow through the fabric, and the effect of flow on porosity of fabric, must be well understood.

Air Force studies are under way to obtain data on air flow vs density (to 150,000-ft equivalent altitude), load vs air flow, and load vs density. Also, cross sections of stressed fabric are being studied to determine what happens to the yarns under various conditions of load and air flow.

Protective textiles—Both space pressure suits and HEF (high energy fuel) handlers' suits require special textiles. Pressure suits require both stretch and stability, combined with impermeability. Stretch and stability can be imparted either by 1) using nylon stretch yarns in one direction with normal yarns in the other, or 2) by mathematically analyzing fabric structures to develop fabrics that are stable until a given yield point is reached.

Fabric coatings are used both for impermeability in pressure suits and protection in HEF handlers' suits. Work is now under way to discover coatings that are impervious to both liquid and gaseous HEF. Materials being studied include polyester film and the fluoroelastomers (Viton, Kel-F Elastomer, and Vyram). Additional requirements for such coated fabrics include resistance to decontaminants such as ammonia and alcohol, flexibility from −40 to 140 F, and ability to be joined with an impervious seam.

THE HIGH TEMPERATURE PROBLEM

Rhenium—A Promising Refractory Metal

by John Port, *Chief Metallurgist, Rhenium Development, Chase Brass & Copper Co.*

■ Although rhenium has the highest melting point (5756 F) of the refractory metals, excluding tungsten (6170 F), it is still too scarce and expensive to be considered for general design applications. However, for many specialized applications the use of rhenium-base alloys and other alloys rich in rhenium is justified by their outstanding properties.

Other properties combine with the high melting point to make rhenium unique among the refractory metals. Following are its principal attributes.

1. Is the most refractory of the metals that can be electrodeposited from an aqueous solution.
2. Is superior to tungsten in resistance to deterioration caused by the "water cycle."
3. Has low contact resistance.
4. Does not form stable carbides.
5. Has greater ductility at room temperature than tungsten.
6. Has good thermoelectric properties when joined with tungsten or molybdenum.

Mechanical properties

Rhenium and its alloys have high mechanical properties. Properties of rhenium are summarized in Table 1. Rhenium, molybdenum-rhenium alloys and tungsten-rhenium alloys have greater room temperature ductility than either tungsten or molybdenum. Fig 1 and 2 give properties for both

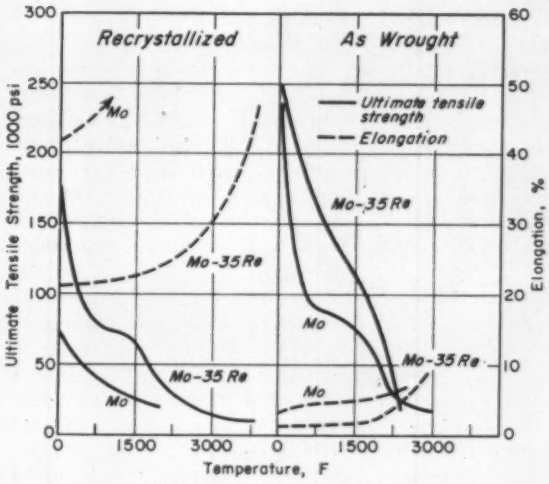
TABLE 1—ROOM TEMPERATURE PROPERTIES OF RHENIUM

Condition →	Annealed Rod[a]	Annealed Sheet[b]	10% Cold Rolled Sheet[b]	20% Cold Rolled Sheet[b]
Yield Strength (0.2% offset), 1000 psi	46	39	255	274
Ultimate Strength, 1000 psi	164	150	272	287
Elongation (in 2 in.), %	24[c]	19	3	2
Modulus of Elasticity, 10^6 psi	66.7 ± 2.9[d]	—	—	—

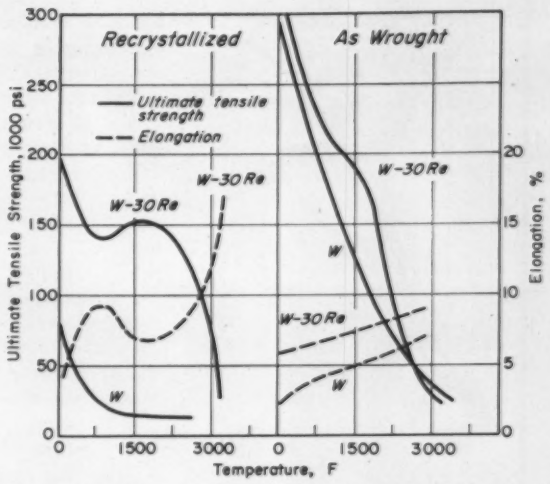
[a]Strain hardening exponent, n, is 0.353.
[b]5-mil sheet.
[c]In ½ in.
[d]Modulus is 54 x 10^6 at 1616 F.

TABLE 2—RHENIUM CONTENT AFFECTS TRANSITION TEMPERATURE

Alloy ↓	Transition Temp, F	
	Wrought	Recrystallized
Tungsten	194	626
Tungsten-30% Re	−130	212-482
Molybdenum	−220	86
Molybdenum-35% Re	−274	>−328



1—*Mechanical properties of wrought and recrystallized Mo and Mo-35 Re. (Battelle).*



2—*Mechanical properties of wrought and recrystallized W and W-30 Re. (Battelle).*

types of rhenium alloys.

Yield strength data lacking— One of the drawbacks of almost all elevated temperature data is evident in Fig 1 and 2. Yield strength, the essential design criterion, is not reported. Instrumentation difficulties combine to make determination of yield data extremely difficult at the high temperatures at which these tests are made. However, some effort should be made in future investigations to report yield properties so that designers and engineers may accurately determine where these highly refractory metals may be applied. Since tensile strength is not a design criterion, rhenium alloys must be applied empirically until yield strength data are available.

Transition temperature — Rhenium, when alloyed with molybdenum or tungsten, significantly lowers the ductile-to-brittle transition temperature of these metals (see Table 2). This suggests that alloying of rhenium be explored further to determine whether or not a similar effect can be found in other metal-rhenium combinations.

Four current applications

1. Welding filler metal

One of the most significant advances in joining molybdenum components has been made with the molybdenum-35% rhenium alloy. When this alloy is used as filler metal in tungsten inert-arc welding, resulting weldments are found to have startling ductility at room temperature. The effect can be seen in Fig 3. The possible applications of molybdenum are broadly increased as a result of the increase in ductility of molybdenum weldments.

Tests at Marquardt Corp. on molybdenum-0.5% titanium that had been tungsten inert-gas (TIG) welded with molybdenum-35% rhenium filler wire disclosed that the weldment contained three zones: two strong, relatively ductile regions—the cold worked parent metal and the alloy weld metal—and the heat affected zone, which is recrystallized molybdenum and is less ductile. Further research to overcome the embrittlement of the heat affected zone is now in progress.

Future developments — Several welding research areas suggest themselves:

1. TIG welding of tungsten components using a tungsten-30% rhenium filler wire.

2. Electron beam welding with a rhenium alloy filler wire to minimize the heat affected zone so that its effect will be insignificant.

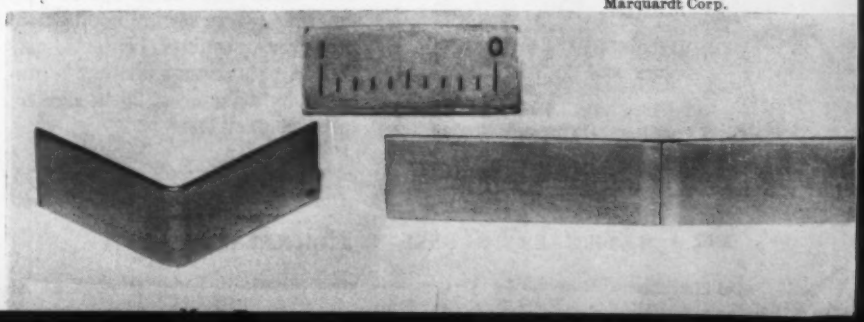
3. Welding with an alloy rich in rhenium, attempting to diffuse the excess rhenium into the heat affected zone. The object would be to either eliminate the heat affected zone or increase ductility of the heat affected zone to the level of the weld and parent metal.

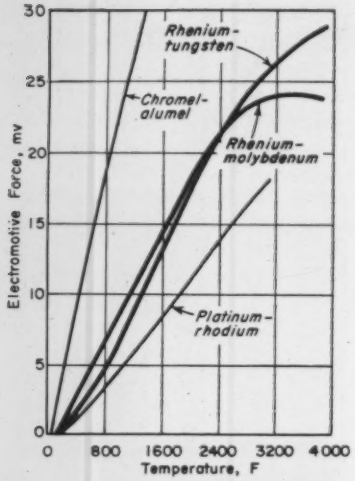
2. Thermocouples

Rhenium-tungsten and rhenium-molybdenum thermocouple combinations provide a significant breakthrough in the accurate

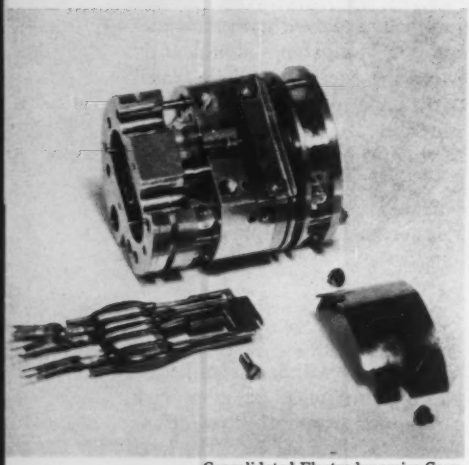
3—*Spectacular improvements in bend ductility of molybdenum TIG-welded with Mo-35 Re filler wire compared with similar weld (right) without filler wire. Weldment bent 82 deg with filler wire and did not fracture; weldment on right fractured after 4 deg bend.*

Marquardt Corp.





4—*Emf vs temperature for rhenium thermocouples compared with two standard thermocouple compositions (after Lachman).*



Consolidated Electrodynamics Corp.

5—*Rhenium filament (lower left) is shown disassembled from the Isatron assembly of the Consolidated Electrodynamics mass spectrometer. Isatron provides the electron source to ionize material being analyzed.*

MORE ENGINEERING & DESIGN

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measurement of extremely high temperatures. Optical pyrometers, while useful, have three important drawbacks at very high temperatures: 1) errors often result from sighting through furnace fumes and glass enclosures; 2) the metal being observed may sublimate; 3) such pyrometers are not easily installed on laboratory scale equipment.

Fig 4 compares the thermal emfs of rhenium-tungsten and rhenium-molybdenum couples with those of other standard thermocouple combinations. Investigation has disclosed that:

1. Rhenium thermocouples are reliable for temperature measurement in vacuum, hydrogen, or inert atmospheres.

2. As shown in Fig 4, rhenium-tungsten thermocouples may be used up to 4000 F; the flat response of rhenium-molybdenum couples above 3200 F limits them to that temperature maximum.

3. Rhenium thermocouples are thermally stable and their calibration is reasonably reproducible.

3. Electrical contacts

Use of rhenium for contacts is the subject of extensive, but largely unpublished, investigation. The high strength and hardness of rhenium provide excellent wear resistance in contacts required to "make and break" repeatedly for a large number of cycles. The relatively low contact resistance remains substantially unchanged during use at moderate temperatures because of the metal's good oxidation and corrosion resistance. An additional reason to consider rhenium for contact applications: the small amount of rhenium oxide that may form is conductive and has nearly as low resistivity as rhenium itself.

This combination of properties has led to the use of rhenium as a contact material in marine magnetos and other similar applications. Improvements in contact life have not been stated. In another severe service application, however, rhenium contacts outlasted platinum-palladium contacts by a factor of 20 in accelerated contact tests.

4. Heaters and filaments in electron tubes

The three principal advantages that rhenium enjoys over tungsten are that it: 1) has greater resistance to the "water cycle" effect (at red heat, water vapor breaks down to hydrogen and oxygen, promoting continuous oxidadation), 2) does not form stable carbides, and 3) does not become brittle upon recrystallization.

Cathode heaters — Rhenium's usefulness as a cathode heater is due to: 1) a resistivity about twice that of tungsten at 1300-1400 F; making it possible to use a larger diameter wire, 2) more ductility after hydrogen firing than tungsten and therefore greater ease of assembly, and 3) greater resistance to the water cycle, which allows a rhenium heater cast in alumina to operate for as long as 1000 hr with no sign of deterioration. Tungsten, after a similar time interval, would show signs of pitting.

Varian Asso. has found that substituting rhenium for tungsten heaters increases heater life by a factor of 100. In this case a Bayard-Alpert ionization gage was used to measure vacuums in the presence of ammonia gas; interaction of ammonia with tungsten reduced heater life to one day. Rhenium heaters lasted about three months.

Another Varian heat application is a tube using titanium as an evaporative getter. Titanium is wound directly on the rhenium wire which is heated until the titanium evaporates.

Mass spectrometer filament— An electron emitter is needed on mass spectrometers in order to ionize the specimen being analyzed. Consolidated Electrodynamics uses the rhenium filament shown in Fig 5. Resistance of rhenium to the water cycle is a major advantage in mass spectrometry, since many samples contain small amounts of water.

Tungsten filaments tend to form carbides (mp 5031 to 5175 F). Rhenium (mp 5756 F) does not form carbides and is less susceptible to accidental burnout.

Missiles and rockets *are forcing materials to higher and higher service temperatures.*

Introduction to High Temperature Metals

Structural metals are now meeting high strength requirements at temperatures from 1200 to 2500 F and reaching for still higher levels. This manual discusses the problems encountered at such temperatures and tells what materials may be able to solve them. Extensive information and data are given for:

- *Iron, nickel and cobalt-base superalloys*
- *Refractory metals and alloys*
- *Borderline and potential materials*

by Jack C. Merriam, *Associate Editor, Materials in Design Engineering*

M/DE Manual No. 172—June, 1960

■ To conquer space and to extend the range of rockets, missiles and aircraft—these projects represent the frontiers of high temperature technology today. Designs and materials must be found for powerplants that consume fuel at high temperatures and for airframes, particularly leading edges, that are subject to great extremes of areodynamic heating. These two fundamental needs are receiving major attention today, and are fostering research and development of materials beyond barriers yet to be met in other fields.

But other fields are expanding their own particular frontiers as well—fields such as nuclear power, commercial aircraft, automotive engines, materials producing, chemical processing and steam power plants. Each such field is meeting head-on its own problems in fabrication, service and cost. As the space age rolls on to meet higher and higher requirements, accomplishments in high temperature materials development and application will be inherited by these fields and lead to increased capabilities and efficiencies.

This manual is concerned with the highest temperatures being faced today by structural materials and will necessarily be devoted primarily to materials problems in the rocket and missile fields. Fig 1 and Table 1 indicate what some of these temperatures are and give an idea of the applications, service times and materials involved.

Many high temperature applications involve essentially non-structural materials such as furnace liners, ablative skins and thermal insulations. They are touched on only briefly in this manual which is limited to materials suitable for structural components.

What properties are important?

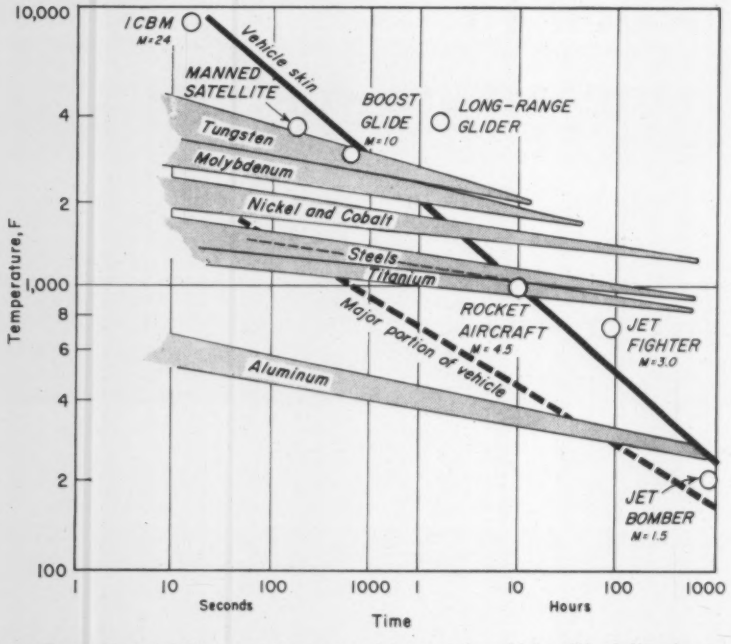
The problem of high temperature is extremely complex. The box on p 146 lists some typical components together with a brief discussion of the problems that each presents at service temperatures.

Stress-time-temperature parameters are the focal point of most materials selection studies. Revolving about these parameters are other properties that also relate directly to service conditions, such as short-time tensile strength or the ability to resist oxidation. Finally, factors other than service conditions must be considered: such things as response to strengthening treatments, the forms in which the materials can be produced, and the ways in which they can be formed and joined.

All properties are affected by the great sensitivity of high temperature materials to the interrelated factors of composition and processing history. The procedures used in producing the material, composition traces and impurities, the amount of prior cold working, and the heat treatments and aging procedures used all have important effects. They determine relative strength levels for different types of loading at particular temperatures (see Fig 2) and they affect structural stability by shifting critical temperature ranges such as the transformation and recrystallization ranges.

Stability—Structural stability is a critical factor which affects both fabricability and service operation. Because of the high mobility of atoms at elevated temperatures, few alloys are stable for long periods of time. For example, age hardened materials may overage, work hardened materials may anneal, and alloys containing many different elements may form new phases and lose strength or become brittle. Some alloys become hot short or brittle in certain temperature ranges.

These stability characteristics also limit the effectiveness of strengthening treatments because such treatments can not always be performed in the most advantageous temperature range.



1 Temperature-time *requirements of future air vehicles (black lines) compared with maximum use temperature ranges of various materials groups (gray bars).* (Battelle Memorial Inst.)

Temperature-time-stress

Temperature and time are parameters of importance to every property of materials that will be discussed throughout this manual. What we mean here by temperature-time-stress, however, are the so-called "long-time" properties — creep and stress-rupture strength — that are generally accepted as criteria for high temperature service. "Long-time" is used in quotes because in many of today's applications the term is now relative. Service during which high stress levels and extreme tem-

TABLE 1—WHERE HIGH TEMPERATURES ARE ENCOUNTERED

	APPLICATIONS	MATERIALS USED
9000 F	Leading edges and nose cones of re-entry vehicles may reach this temperature for times of a few seconds to a half minute.	No material can withstand this heat, but it can be dissipated by ablation, conduction or cooling media so that the structural skin material must withstand temperatures in the range of 2500-3500 F.
5000 F	Nuclear powered rocket motors will achieve this temperature with heat exchanger designs using gaseous propellants. Solid-fuel rocket engines heat critical areas to this temperature now.	Complex designs providing cooling, insulation and lowering of thermal shock are necessary to allow materials to stand such exposure for more than a few seconds. Time may be as short as 2 or 3 sec, in which case alloy steels may be used as well as high temperature alloys. Graphite and phenolic resins reinforced with quartz can meet this temperature for a few minutes.
3000 F	Manned satellites, and boost and long-range gliders must have skins to meet temperatures at least this high.	At present tungsten and tantalum alloys seem to offer the most promise. Molybdenum alloys can maintain adequate strength for times on the order of 1 min.
2500 F	Turbojet combustion chambers and nozzle vanes, and ramjet flame holders and combustion sections are reaching for temperatures on this order to achieve greater power and efficiency. Time involved is not long, may range from several seconds to several minutes.	Molybdenum alloys, cermets, and composite or ceramic-coated alloys are the only ones expected to meet the requirements.
2000 F	All components of ramjet engines where stresses are lower than in turbojets are meeting this temperature today.	Columbium alloys offer potential, but cobalt alloys are being widely used. It is at this temperature that oxidation of the refractory metals begins to be a serious problem, though it has been fairly well solved for columbium and molybdenum up to about 2500 F.
1800 F	Gas turbine buckets, nozzle vanes and combustion chambers of turbojet engines are meeting this temperature requirement today in extreme cases.	Cobalt alloys are necessary if times are to be on the order of hundreds of hours. This temperature is about the upper limit of usefulness of the nickel superalloys. Where stresses are low, as in turbojet afterburner nozzles, austenitic stainless steels can be used.
1500 F	Compressor sections and turbine wheels of turbojets, combustion chambers of turbojet afterburners, and cooler sections of ramjet engines reach temperatures of this order.	From this temperature down the material used depends highly on stress levels, service times and corrosion problems. The nickel superalloys meet the highest requirements, then the iron superalloys which contain chromium, nickel and sometimes cobalt. In cases of short time or low stress levels, alloys generally suited for temperature levels below 1200 F are used.
1200 F	Engine parts of various types, skins of aircraft, and, recently, steam turbine inlets and blades are among the many applications requiring 1200 F operation.	Where times are of the order of hundreds, or even thousands, of hours and stress levels are high, iron superalloys are used. At lower stress levels austenitic stainless steels or 12% chromium martensitic stainless are satisfactory. For shorter times the martensitic tool steels generally recommended up to 1000 F are finding use. Where stresses are very low titanium alloys and precipitation hardenable semi-austenitic stainless steels are used, particularly for times less than 20 min. Where light weight and high elastic modulus are important beryllium alloys find application.

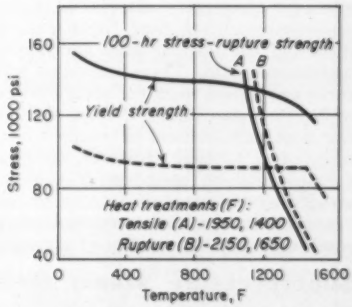
peratures are encountered for a few hours, minutes, or even seconds, is, in terms of materials deformation and stability, long-time service.

The relationship of creep and stress-rupture data to design is no longer as direct as in the past. Service conditions are more complex, involving such considerations as heat flux, rate of heating, and range and frequency of thermal cycling. The need for suitable test methods and more adequate data, as well as the significance of available data, is discussed later. Despite their drawbacks, creep and stress-rupture tests remain of major importance.

Other service requirements

What combination of other properties may be required by the particular application? For convenience, they may be classified as mechanical, thermal and environmental.

1. Mechanical—Many combinations of mechanical loads are imposed on today's airframes and powerplant components. These applications require knowledge of such properties as: short-time tensile strength, short-time yield strength, elongation, ductility, impact strength, fatigue



2 Strengthening treatments *of superalloys such as René 41 must be chosen to fit the service requirements.* (Flight Propulsion Div., General Electric Co.)

Service Requirements for Specific Applications

Gas turbine blades and wheels Requirements for blades include not only resistance to rupture and creep at high stress for hundreds of hours, but also resistance to thermal shock, thermal fatigue, impact and oxidation. Turbine wheels, on the other hand, operate at lower temperatures than the blades, and must be designed from the standpoint of stress-rupture and yield strengths. Highest temperatures may range from 1800 F to 2500 F for buckets, but only 400 to 1600 F for wheels. Both blades and wheels must be capable of satisfactory fabrication and must be weldable if at all possible.

Compressor blades Required to meet lower temperatures but, along with ease of fabrication and resistance to impact, fatigue and oxidation, must have such additional qualities as damping capacity, and resistance to intergranular and stress corrosion cracking. Strategic alloy content and cost must be low because mass is large. Cost generally rules out the superalloys and requires reliance on stainless steels.

Ramjet exhaust nozzles Here, for comparison, is a case where resistance to temperatures of 2700 to 5400 F is by far the major criterion. Though average fabrication ability and some degree of resistance to thermal shock are needed, stresses are low and times are short enough (generally 50 hr or less) to obviate fatigue worries. Unlike the case of rotating parts, here impact and vibration is a minor consideration.

Rocket engine exhaust nozzles Service life is very short (a few seconds to a few hours) but temperatures may exceed 5400 F and problems stated above are intensified because erosion and oxidation by the high velocity exhaust stream, as well as thermal shock, now cause great difficulty. Nozzle materials problems, like those of all rocket engine parts, are further complicated by such factors as the type of fuel and oxidizer, whether the fuel is solid or liquid, and the duration and severity of operation. Regenerative cooling and ceramic coatings or linings make it possible to use materials at lower temperatures than that of the actual service environment.

Afterburner fuel spray bars Thermal shock resistance becomes the major criterion here. When the afterburner is not operating, turbine exhaust temperature keeps the bars at 1200-1500 F. The moment fuel enters the afterburner, the wall temperature drops to 200 or 100 F.

Ramjet combustion chambers The chamber is a thin-walled pressure vessel subject to varying pressures and cantilever loads that create large vibrations and fluctuations of the skin material. Fabrication of the chamber involves rolling and welding of cylinders and cones. In this case ability of welds to withstand the 1800 to 2200 F temperatures and vibration loads is of major importance in selecting materials.

Uncooled liquid propellant rockets With temperatures of 6000 F or higher, even for a few seconds, there is no particular advantage in using materials other than mild steel or such alloys as 4130 steel because all metals deteriorate rapidly.

Airframes Resistance to high temperature is a major problem in airframes, but the temperatures to be met vary from a few hundred degrees for commercial aircraft to perhaps 10,000 F for the leading edges of some re-entry vehicles. Temperature also drops rapidly within a few inches of the leading edge and may be lower for the top skin than the bottom side skin. Those materials which must meet the highest temperatures are chosen more for their heat resistance than for strength. Nature of loading also varies widely. Conventional aircraft structures are, for the most part, critical in compression. For missiles the critical loads are more often tensile. However, different design approaches make the difference between compressive and tensile loading even when the basic structures appear similar. A third type of body—that of solid-propellant-fuel rockets—maintains tensile loading during burnout and then, as flight continues, may become loaded primarily in compression.

Superpressure steam turbine One example outside the missile and rocket field is the Eddystone steam power plant which requires the superpressure turbine materials to meet 1200 F and 5000 psi for long service times. In this design additional factors were adequate strength at room temperature, long-time stability at 1200 F, optimum thermal expansion characteristics, and materials availability.

strength, shear strength, bearing strength, notch-impact and notch tensile strengths, and modulus of elasticity.

In addition, thermal mechanical properties, such as thermal shock and thermal fatigue, are of extreme importance though few or no data are available for most materials. Thermal failures result from sudden, intermittent or widely fluctuating temperatures.

Structures with low strength-weight ratios are still a fundamental requirement for most applications at high temperature. In airborne vehicles the penalty exacted by one extra pound of structural weight multiplies because of the extra fuel and power needed which, in turn, add weight and require added lift.

A final factor which must be considered is that materials which satisfy strength requirements at high service temperatures may have limitations that cause problems at other temperatures. Some alloys that *maintain* their strength levels at high temperatures do not necessarily possess high strength, per se, in relation to other materials at lower temperatures. Some alloys that have operated at service temperatures for a time will have lower strengths at lower temperatures than they did before service. Some alloys are adequate for service stresses but lack ductility at room temperature.

2. Thermal—Physical thermal properties, such as coefficient of thermal expansion, thermal conductivity, emissivity and melting point, are important design factors in elevated temperature service.

Thermal stresses resulting from differential expansion of parts subjected to different temperatures or the differential expansion at a joint between metals having different coefficients of expansion can produce 50% or more of the total applied load on a part. Many cases of failure resulting from differential thermal expansion are on record. In general, a low coefficient of expansion is desired. However, equally important in the case of dissimilar metal joints is an equivalent coefficient of thermal expansion, high or low.

Thermal conductivity becomes critical in applications such as combustion chambers where it is important that heat be rapidly distributed and dissipated. This is especially true where uneven combustion produces hot spots. Most high temperature alloys have comparatively low thermal

conductivity; thus differential heating and hot spots can easily lead to severe distortion and actual burning of the metal. Thermal stresses causing failure are often the result of inability to distribute heat evenly throughout a part.

Emissivity is a property only recently considered seriously by the powerplant designer. It is important in combustion chambers to have an inside surface with as low an emissivity factor as possible in order to reflect the maximum radiated heat from the combustion gases. On the other hand, a ramjet engine combustion chamber outer surface is open to the sky and should have as high an emissivity factor as possible to radiate maximum heat from the wall to the sky. The factor of emissivity can result in hundreds of degrees difference in operating wall temperatures.

Melting points of alloys bear a direct relationship to the maximum service temperatures. In general, present structural materials capable of unprotected operation at temperatures above 1500 F melt below 2700 F.

3. Environmental—Resistance to scaling, oxidation and chemical corrosion are major properties to consider.

The problem is not a straightfoward one, however. For example, although oxidation generally leads to low strength, some metals actually lose strength or ductility because they are protected from oxidation through coatings or reducing atmospheres. This is because internal oxidation may strengthen metals around intercrystalline cracks, or solid solution alloying may occur with oxygen from the atmosphere.

Temperature and the nature of the environment determine the kind of reaction that will occur, as well as the rate at which it will occur. Because protective coatings seem to offer the most hope in this area, the properties of coatings may be more important than the properties of the structural materials themselves.

Fabricability

The forms in which high temperature materials are available, and their relative degree of fabricability and joinability, are factors which depend on the metallurgy of the alloys. Because the alloys are metallurgically sensitive, difficulties exist in these three areas:

1. Forms available for many alloys are limited, i.e., the alloy may be available only as a casting alloy, in bar form, powder, etc. One of the most important needs, for example, is for large, thin sheets of many alloys for airframe structures.

2. Fabrication of many alloys requires special care, treatment, environment, technique or equipment. For example, some alloys are difficult to machine. Some require that forming be done warm (at temperatures of 400 to 800 F) or in special atmospheres. Others work harden rapidly and require many intermittent anneals with fast cooling to avoid precipitation phases.

3. Joining presents the same types of difficulties as fabrication. Welding problems sometimes are such that high temperature brazing or mechanical fastening is the only answer. Some alloys require pre- and post-heating; some are subject to hot shortness and cracking. The highest temperature alloys must be welded in inert-gas-filled chambers.

What materials are available?

In defining materials groups from which particular materials may be selected for service within the range from 1200 F to about 3500 F, it is impossible to designate specific groups for particular temperatures. To do so would require reference to the complicating factors of thermal cycling, types and degrees of stress, service times, environmental conditions and types of application, as well as individual discussion of each alloy. However, for the purposes of a preliminary introduction to the materials, the groups have been loosely classified as:

1. Primary materials, which are able to withstand more than 10,000 psi (stress-rupture) for 100 hr at indicated temperatures ranging from 1200 to 2000 F.

2. Borderline materials, which are able to withstand about 10,000 psi (stress-rupture) for 100 hr at temperatures not much above 1200 F.

3. Potential materials, which in general can withstand extremely high temperatures but are limited by some essential type of strength.

The borderline and potential materials are discussed in boxes on pp 150 and 152. The primary materials groups are discussed below. Property data in this manual are given only for the primary groups.

The primary materials can be divided into two major groups: the superalloys and the refractory metals. These groups, in turn, can be subdivided broadly on the basis of composition. The following two sections discuss the advantages and limitations of these groups. Representative alloys within each group are identified in Table 2. No attempt has been made to include all available alloys.

Superalloys

This group of materials is the primary one for applications from 1200 to about 2000 F. It can be divided into iron-base (including complex base), nickel-base and cobalt-base alloys. Forms included are forgings, bar, sheet and castings, although most alloys are not available in all forms. The following discussion applies generally to all the wrought forms. The cast alloys are discussed independently.

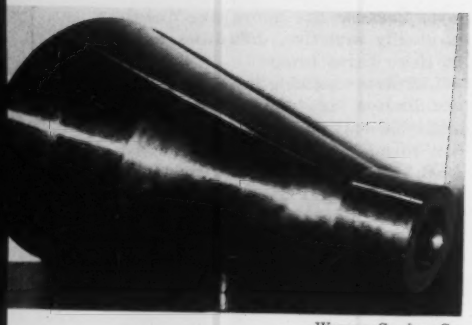
The three groups

1. Iron-base (and complex base)—The term "iron-base" usually refers to proprietary iron-chromium-nickel austenitic stainless steels that are work hardenable, such as 19-9 DL, or age hardenable, such as A-286. They retain their strength up to about 1400 F.

A second group that can be included in the "iron-base" category are the complex-base iron-chromium-nickel-cobalt alloys (such as N-155) which are widely used in the 1200 to 1500 F range. These alloys are generally hot-cold worked for service at the lower temperatures of their range, or solution treated for higher service temperatures.

A third and entirely different type of iron-base superalloy retains strength only to about 1000 F and is not included in the discussion. These contain 10 to 18% aluminum and 2 to 4% molybdenum and are designated as Thermenols. They have low density and excellent resistance to corrosion and oxidation.

2. Nickel-base—The term "nickel-base superalloy" usually refers to those which contain more than 50%



Wyman Gordon Co.

Superalloys, *such as René 41 nickel-base alloy, are used from 1200 to 2000 F. This is part of a jet engine turbine rotor used to transmit power from the turbine to the compressor.*

nickel, additions of aluminum and titanium as hardening agents, and various elements such as molybdenum and columbium for increased high temperature strength. There are more alloys in this group than in any other. Their superior yield and creep strengths, oxidation resistance and alloying potential make them to a considerable extent the preferred superalloys in the 1500-1800 F range. Some of these alloys, such as René 41, are vacuum melted.

A second group is the solid solution types, such as the Hastelloys which are alloyed with molybdenum and tungsten. Precipitation hardening treatments are slightly effective if the service temperature is 1300-1900 F, but the alloys are generally used in the solution treated condition.

A third group sometimes considered nickel-base alloys is really a complex-base group containing about 40% nickel, with chromium and iron as major constituents and titanium and molybdenum as minor constituents that allow some degree of age hardening. Typical of this group is Incoloy 901 which matches the high temperature strength properties of other nickel superalloys only up to 1350 F. This group may also be included in the iron-base superalloy category.

3. Cobalt-base—This group, until recently deemed the best for service from 1600 to perhaps 2200 F, is losing way to the precipitation-hardenable nickel superalloys but still has advantages above 1800 F where the nickel group may become unstable. The cobalt group are mixed-base alloys of chromium-nickel-cobalt that contain fairly high percentages of columbium, tungsten or molybdenum. At the high end of the temperature range, Haynes Stellite No. 25 (L-605) is the most widely used alloy, though it has a high critical alloy content. In addition to having the highest strengths at temperatures close to the 2000 F mark, the cobalt alloys have excellent oxidation-corrosion resistance.

Many of the cobalt superalloys are fabricated only by casting, though some are available in both wrought and cast forms. Because of the difficulty in machining the cobalt alloys, complicated parts such as turbine blades and nozzle segments are investment cast to finished shape.

Structure, stability and fabricability

Those alloys which have the highest stress-rupture strengths at high temperatures are generally vacuum melted. This process also improves ductility and therefore fabricability. Vacuum melting is able to have such marked effects because of the structural sensitivity of the superalloys.

Structure—Although the superalloys are grouped above according to their major base, they all contain enough nickel to make the structure austenitic. In the iron and nickel-base groups, most of the wrought alloys and many of the sheet alloys are age hardening (or precipitation hardening) types, rather than solid solution types, by virtue of the addition of small amounts of aluminum and titanium in varying proportions.

Stability—Age hardening with the aluminum-titanium system is reversible, which makes it possible to recover any loss of strength due to overaging. (Overaging can occur in long-time service at high temperatures when heating is too prolonged; it leads to softening.) As temperatures decrease some of the age hardening phase reprecipitates, restoring most of the original strength. These precipitation hardening types generally have higher yield strengths, slightly lower ductility and, most important, higher stress-rupture strengths than solution hardening alloys.

No satisfactory precipitation hardening systems have yet been developed for cobalt superalloys. For their high temperature strength they depend upon solid solution alloying with tungsten and molybdenum and, in some cases, a dispersion of stable carbides. These alloys therefore generally compete with nickel alloys only above 1800 F when the age hardening phase of the nickel group becomes unstable.

Stress-rupture strength of some of the alloys can be increased by moderate amounts of cold working. The nickel-base superalloys exhibit greater strengthening effects from work hardening than the cobalt-base alloys. However, since cold working lowers the recrystallization temperature, the nickel group loses its strength at lower temperatures than similarly worked cobalt alloys.

Fabricability—The iron-base alloys have excellent ductility and are therefore more easily formed and fabricated than the others. The nickel-base group is generally more workable than the cobalt-base, though the precipitation hardening types have extremely low ductility in the 1000 to 1400 F range.

In alloys where cold working is used for strengthening, ductility is not reduced enough to make forming difficult. In others, where heat treatment is used to obtain maximum strength, ductility is often affected. Forming and fabricating in these cases should be done in the annealed condition and heat treatment performed afterward.

Forging and hot working of the alloys is feasible, but the higher the service temperature of the alloy, the more difficult is the forging and the narrower is the temperature range in which substantial reductions can be made. The upper end of the range is limited by such factors as grain size control and the lower end by alloy stiffness.

Machining superalloys is considerably more difficult than machining the standard stainless steels. In general, machinability decreases with increasing service temperatures, thus rating iron-base alloys as the easiest to machine, nickel-base next, and cobalt-base the most difficult. However, the precipitation hardenable alloys often can be readily machined in the solution treated state. This is true of most nickel and iron-base alloys. There is a drawback in some cases, though: the solution treated material work hardens rapidly during machining. The cast alloys, particularly the cobalt-base, are the most difficult to machine.

Weldability depends on the individual alloy more than on the superalloy group to which it belongs. The cobalt alloys seem to have a slight edge in ease of weldability. Among the other groups, the age hardening

TABLE 2—COMPOSITIONS OF SOME HIGH TEMPERATURE ALLOYS[a]

Alloy	Form[b]	C	Mn	Si	Cr	Ni	Co	Mo	W	Cb[c]	Ti	Al	Fe	Other
IRON-BASE														
A-286	W	0.05	1.35	0.95	15.50	26.0	—	1.25	—	—	1.95	0.20	Bal	V 0.30
D-979	W	0.05	0.50	0.50	15.0	45.0	—	3.75	3.75	—	3.0	1.0	Bal	B 0.01
Discaloy	W	0.04	0.9	0.8	13.5	26.0	—	2.75	—	—	1.75	0.07	Bal	—
Incoloy 901	W	0.05	0.50	0.35	13.0	40.0	—	6.0	—	—	2.50	0.20	Bal	B 0.03
N-155, Multimet	W, C	0.10	1.50	0.70	20.75	19.85	19.50	2.95	2.35	1.15	—	—	Bal	—
Refractaloy 26	W	0.03	0.8	1.0	18.0	38.0	20.0	3.2	—	—	2.6	0.2	Bal	—
Refractaloy 70	W	0.04	2.0	0.3	20.0	21.0	30.0	8.0	4.2	—	—	—	Bal	—
S-590	W	0.4	1.5	0.6	20.0	20.0	20.0	4.0	4.0	4.0	—	—	Bal	—
Unitemp 212	W	0.08	0.05	0.05	16.0	25.0	—	—	—	0.50	4.0	0.15	Bal	B 0.06, Zr 0.05
V-57	W	0.06	0.25	0.55	14.75	25.50	—	1.25	—	—	3.0	0.25	Bal	B 0.008, V 0.30
W545	W	0.05	1.50	0.40	13.5	26.0	—	1.50	—	—	2.85	0.20	Bal	B 0.08
16-25-6	W	0.08	1.35	0.70	16.25	25.5	—	6.0	—	—	—	—	Bal	N 0.15
19-9DL	W	0.30	1.10	0.60	19.0	9.0	—	1.25	1.20	0.40	0.30	—	Bal	—
NICKEL-BASE														
Cosmoloy F	C	0.04[d]	0.10[d]	0.10[d]	15.0	Bal	—	3.8	2.2	—	3.4	4.7	0.20[d]	B 0.08, Zr 0.07
GMR-235	C	0.15	0.25[d]	0.60[d]	15.5	Bal	—	5.25	—	—	2.0	3.0	10	B 0.06
Hastelloy B	W, C	0.05[d]	1.0[d]	1.0[d]	1.0[d]	Bal	2.50[d]	28.0	—	—	—	—	5.5	V 0.4[d]
Hastelloy C	W, C	0.08[d]	1.0[d]	1.0[d]	15.5	Bal	2.50[d]	16.0	3.75	—	—	—	5.5	V 0.35[d]
Hastelloy X	W, C	0.10	1.0[d]	1.0[d]	22	Bal	1.5	9.0	0.6	—	—	—	18.5	—
Inconel 700	W	0.13	0.08	0.25	15.0	46.0	29.0	3.0	—	—	2.20	3.20	0.80	—
Inconel 702	W	0.04	0.10	0.25	15.50	79.0	—	—	—	—	—	3.0	0.50	—
Inconel 713C	C	0.12	0.15	0.40	13.0	Bal	—	4.50	—	2.25	0.60	6.0	1.0	—
Inconel X	W	0.04	0.70	0.30	15.0	73.0	—	—	—	0.90	2.50	0.90	7.0	—
M-252	W	0.10	1.0	0.70	19	54	10	10	—	—	2.5	0.75	2.0	B 0.0005
Nicrotung	C	0.10	—	—	12.0	Bal	10.0	—	8.0	—	4.0	4.0	—	B 0.05, Zr 0.05
René 41	W, C	0.12	0.1	0.5	19.0	Bal	11.0	10.0	—	—	3.1	1.5	—	—
Udimet 500	W	0.15[d]	0.75	0.75	17.5	Bal	16.5	4.0	—	—	3.0	2.75	4.0[d]	B 0.008[d]
Udimet 700	W	0.15[d]	—	—	15.0	Bal	17.5	5.0	—	—	3.5	4.25	1.0	B 0.10[d]
Waspaloy	W	0.05	0.50[d]	0.75[d]	19.50	Bal	13.5	4.25	—	—	3.0	1.25	2.0[d]	B 0.005, Zr 0.06
1753	W	0.24	0.05	0.10	16.25	50.0	7.20	1.60	8.40	—	3.15	1.90	9.50	B 0.008, Zr 0.06
COBALT-BASE														
HS-21	C	0.25	1.0[d]	1.0[d]	27.0	2.75	Bal	5.5	—	—	—	—	2.0[d]	B 0.007
HS-25, I-602	W	0.10	1.5	1.0[d]	20.0	10.0	Bal	—	15.0	—	—	—	3.0[d]	—
Nivco	W	0.02	0.35	0.15	—	22.5	Bal	—	—	—	1.8	0.22	1.0	Zr 1.1
S-816	W	0.38	1.32	0.56	20.0	20.0	Bal	4.0	4.20	3.7	—	—	5.0[d]	—
V-36	W	0.30	0.90	0.40	25.0	20.0	Bal	4.0	2.3	2.0	—	—	2.0	—
X-40, HS-31	C	0.50	1.0[d]	1.0[d]	25.5	10.5	Bal	—	7.5	—	—	—	2.0	—
REFRACTORY														
Chromium (pure)	W	—	—	—	Bal	—	—	—	—	—	—	—	—	—
Cr-1 Ti	W	—	—	—	Bal	—	—	—	—	—	1.0	—	—	—
Columbium (pure)	W	—	—	—	—	—	—	—	—	Bal	—	—	—	—
Cb-10 Ti-10 Mo	W	—	—	—	—	—	—	10	—	Bal	10	—	—	—
Cb-15 W-5 Mo-1 Zr	W	—	—	—	—	—	—	5	15	Bal	—	—	—	Zr 1
Molybdenum (pure)	W	—	—	—	—	—	—	Bal	—	—	—	—	—	—
Mo-0.5 Ti	W	0.026	—	—	—	—	—	Bal	—	—	0.47	—	—	—
Mo-0.5 Ti-0.07 Zr	W	0.017	—	—	—	—	—	Bal	—	—	0.46	—	—	Zr 0.074
Tantalum (pure)	W	—	—	—	—	—	—	—	—	—	—	—	—	Ta Bal
Ta 90-W 10	W	—	—	—	—	—	—	—	10	—	—	—	—	Ta 90
Tungsten (pure)	W	—	—	—	—	—	—	—	Bal	—	—	—	—	—

[a] Compositions vary slightly with different manufacturers.
[b] W = wrought; C = cast. Where both forms are available, composition given is for wrought form.
[c] Cb+Ta.
[d] Maximum.

types are often subject to cracking and, in addition, are better welded by inert-arc processes to prevent oxidation of the titanium and aluminum. These alloys must be welded in the solutioned condition, and the subsequent solutioning for homogenization and aging for maximum strength must be done with care to avoid distortion.

Cast superalloys

Although the majority of superalloys are used as sheet or bar, castings are important in many applications involving complex shapes, par-

Borderline Materials: Short Times or Low Stresses

A number of materials that are generally rated for service at temperatures 100 or 200 degrees below 1200 F (the minimum considered in this manual) can be used at higher temperatures for short times and/or at low stresses. The so-called borderline materials mentioned here, in general and under average service conditions, can withstand 10,000 psi for 100 hr at 1200 F.

In addition to these materials, there are alloys from other groups of materials—cast irons, low alloy steels, magnesium-thorium alloys, aluminum alloys, ferritic stainless steels, etc.—which can be used at 1200 F in special applications where unstressed parts and/or extremely short times (e.g., less than 2 min) are involved. Materials for such applications will not be discussed here.

1. *Martensitic stainless steels* (standard grades) containing 11.5 to 14% chromium have fairly high strength, but corrosion and embrittlement problems limit their use above 1050 F. However, proprietary modifications of this group, such as Lapelloy which has been used in steam turbines, are the strongest of the martensitic steel alloys above 1100 F. Limited development work is being done on these alloys to extend their strength to higher temperatures, but significant improvement is improbable.

2. *Semi-austenitic stainless steels* (precipitation hardening) are proprietary alloys that have good resistance to corrosion and oxidation and a good balance of properties. They are widely used up to 1000 F but their strength limits them to mild service at temperatures not much above 1200 F.

3. *Martensitic tool steels* (hot work) can be tempered at much higher temperatures than other steels for the same level of strength and thus offer greater resistance to softening at higher temperatures. From 400 to 1000 F they have the highest strength-weight ratio of the commercial structural alloys. Heat treating, welding and fabrication present problems. These steels, such as Chromalloy and Vascojet 1000, have only recently become available as sheet, plate and other semifinished mill products and offer promise for further development which may extend their temperature range. Alloys containing high percentages of such elements as vanadium, tungsten and molybdenum are being developed. Improvement in room temperature ductility is needed.

4. *Austenitic stainless steels* (standard). Types such as 304, 310, 316, 321 and 347 continue to make up the bulk of high strength steels used by the aircraft industry. They have fairly good strength, excellent fabrication characteristics and good corrosion resistance. Where requirements are moderate they are used in applications up to 1500 F. Where scaling resistance and not strength is the criterion, type 310 is used as high as 2200 F. The majority of high temperature applications, however, fall just below 1200 F.

5. *Titanium alloys* as a group are generally used for service below 1000 F. However, newer alloys such as the all-beta B120VCA, 13V-11Cr-4Al (both Crucible Steel) and 8Al-8Zr-1Cb show promising properties up to 1200 F— and up to 1400-1500 F for times of less than 10 min. (The all-beta alloys offer better formability, ductility and weldability.) Titanium alloys offer high strength-weight ratios and undoubtedly have a potential for strength at higher temperatures that still remains to be developed. Service temperatures at present are only about 45% of the melting point of titanium, considerably below the relative service temperatures of other alloy systems.

ticularly since many of the superalloys present machining and forming problems. Cast alloys are available in every group. The iron-base alloys find the greatest application as castings, but cast nickel and cobalt superalloys are gaining acceptance to meet the demand of higher and higher turbine inlet temperatures.

When compared with wrought alloys, cast alloys generally provide equivalent strength at temperatures about 50 degrees higher. However, wrought alloys offset this advantage with better ductility, impact strength and fatigue strength, as well as superior tensile properties at room temperature.

Most iron-base cast alloys have standard American Casting Institute (ACI) designations and fall into three groups:

1. Iron-chromium (e.g., ACI type HA), with 8 to 30% chromium and under 7% nickel.

2. Iron-chromium-nickel (e.g., ACI type HK, corresponding to wrought stainless type 310), with 19 to 32% chromium and 8 to 22% nickel.

3. Iron-chromium-nickel (e.g., ACI type HW).

The second and third groups are more useful than the first at temperatures up to 2100 F. The second group offers primarily high creep strength and ductility; the third resistance to thermal shock and thermal cycling.

Cast alloys finding wide use among the nickel-base group are GMR-235 and 713C; among the cobalt group, Haynes Stellite 21 (vitallium) and 31 (X-40). The nickel-base cast alloys have high rupture strength and fatigue resistance to about 1700 F. The cobalt-base alloys have a good balance between strength and ductility at high temperatures, as well as fairly good room temperature ductility. At temperatures from 1600 to 2000 F, strength stability of these casting alloys is excellent.

Refractory metals

Table 3 lists those refractory metals which have melting points above 3400 F. Work with alloys of these metals is still very much in the research and development stage, though they seem to hold the most promise for applications requiring

TABLE 3—MELTING POINTS OF REFRACTORY METALS (F)

Tungsten	6170
Rhenium	5740
Tantalum	5425
Osmium	4900
Molybdenum	4760
Ruthenium	4500
Iridium	4449
Columbium	4380
Rhodium	3571
Chromium	3430
Vanadium	3150
Hafnium	3100

strength above 2000 F. Those metals which are the object of most attention are tungsten, tantalum, molybdenum, columbium, and possibly chromium. These materials have approximately the same strengths at the same homologous temperatures (i.e., same percent of melting point).

The refractory metals are generally produced in the form of a powder (sponge) which is consolidated before further processing by one of three methods: powder metallurgy (hydrostatic pressure methods now produce large ingots); arc casting, the method which produces present molybdenum alloys and is also being applied to superalloys; and electron beam melting, a method for obtaining high purity but limited in alloying ability and most advantageous for columbium and tantalum.

As a group the refractory metals show high strength properties over a wide range of temperatures above 1600 F, although properties at room and moderate temperatures are considerably lower than those of the superalloys. Columbium and tantalum have better low temperature ductility than the others.

In addition to warm working, the elevated temperature strength of refractory metals may be improved by alloying to obtain solid solutions, interstitial solutions and dispersions of insoluble compounds. Further study in all of these areas is being carried on at the present time.

Unfortunately, the refractory metals are characterized by extremely poor high-temperature oxidation resistance. Alloying has been shown to reduce this problem to some extent but much work is still needed in this area. At the present time it is necessary to rely on coatings, many of which themselves are still in the development stage. It is believed that with the development of suitable coatings, alloys of tantalum and molybdenum, in particular, might be used for applications up to 4000 F and higher.

Other problems yet to be satisfactorily overcome with refractory alloys include difficulties in fabrication and welding. Such operations as forging, spinning and sheet forming can be conducted in air using conventional equipment. However, metals subject to low temperature brittleness, such as tungsten, molybdenum and chromium, require forming at temperatures above the transition temperature.

Tantalum

Tantalum seems to offer the possibility of producing alloys with high strength above 3200 F. Pure tantalum which exhibits better ductility and toughness than the others (except columbium), can be rolled easily at room temperature. However, it has high density, second only to that of tungsten.

Relatively little research work has been done as yet, primarily because of tantalum's scarcity and extremely high cost. However, a tantalum-tungsten alloy recently made commercially available is said to be as strong as tungsten up to 5100 F, to be readily worked below 1000 F, and to have good impact resistance down to subzero temperatures. The alloy (90% tantalum, 10% tungsten) was produced by using an electron beam furnace which keeps traces of iron, cobalt and nickel to extremely low levels.

Chromium

Chromium is the highest melting metal that is reasonably plentiful and offers good oxidation resistance. It has a serious drawback, however: it is extremely brittle at room temperature and thus impossible to form. Two approaches that offer some hope are powder metallurgy and a special process for preparing "ductile" chromium from high-purity electrolytic chromium. At best chromium alloys will surpass the superalloys but perhaps be useful only up to about 2000 F because of strength limitations.

Columbium

Columbium has suffered from delays in research. Only recently have deposits been found that indicate that, far from being the most scarce of the five metals, it is the most plentiful. Columbium is still not commercially available to the same extent as tungsten and molybdenum. The metal has good ductility and low density, and it can be formed. It has been used as a minor alloying element in stainless steels and superalloys.

Alloys of columbium should prove to have good strength up to about 2800 F, though attempts to improve the oxidation resistance of columbium by alloying have led to a decrease in its ductility and fabricability. Two alloys that have just become available commercially are a columbium-zirconium alloy and a columbium-tantalum-zirconium alloy. Limited data are available as yet. The bi-alloy is said to have the same oxidation resistance as pure columbium, the tri-alloy somewhat less. Both are said to be easily fabricated at room temperature, and to have excellent weldability. The tri-alloy has the lower strength-weight ratio.

Tungsten

Tungsten has the highest melting point of all metals but is also one of the most dense. The commercial metal is hard, brittle, and difficult to form and machine. Nevertheless, parts have been formed using high temperatures and high rates of deformation (M/DE, June '59, p 74).

Tungsten alloys—none have been developed yet—should have the highest extreme-high-temperature strength of the refractory metals, and, it is hoped, improved fabricability and oxidation resistance. The oxidation resistance of tungsten is known to be limited at temperatures above 2100 or 2200 F but only a small amount of research has been done in this area.

Molybdenum

Molybdenum, the last of the five refractory metals under discussion, has benefited from the most extensive research and development conducted to date in this field. Molybdenum is presently the most available of these metals, and several promising molybdenum alloys with better hot strength and higher recrystallization temperatures have been developed. These alloys are, at the present time, the strongest available metals for use at temperatures above 1600 F.

The only alloy commercially available in any quantity is 0.5% titanium bar alloy which is stronger than unalloyed molybdenum and has a recrystallization temperature several hundred degrees higher. A variation of this alloy contains an additional 0.07% zirconium. Experimental work is being done on alloying many elements with molybdenum, particularly tungsten, rhenium and zirconium, and metallic oxides to effect disper-

Potential Materials: Modifications Are Needed

1. *Beryllium* has received considerable attention recently as a newcomer to the structural field. The unalloyed metal retains useful strength up to about 900 F. Because of its very low density and very high modulus of elasticity, and despite its low ductility, beryllium is believed to have potential for high temperature use. Considerable alloy research and development work is under way at present.

2. *Cermets.* Within the last few years cermets—metal-bonded carbides, borides, oxides, silicides, nitrides, etc., fabricated by powder metallurgy methods—have failed to show development of their potential for use as structural parts at temperatures up to 2000 F or higher. It was hoped that such combinations would be able to take advantage of both the high temperature strength, stability and oxidation resistance of the refractory ceramics and the ductility and shock resistance of the metallic binder. Unfortunately, poor impact strength and poor short-time ductility are still two of the biggest drawbacks to the use of cermets.

Fabrication difficulties are encountered too. Powder metallurgy places restrictions on the sizes and shapes of parts. Progress has been made in this area, however, by plasma jet and other flame spraying processes which build up a part by spraying a cermet on an expendable pattern (M/DE, Apr '59, p 98) and by use of the plasma jet flame. Nevertheless, at the present time, cermets find more application as protective coatings than as structural parts.

The cermets most successful for structural parts today are: a) tungsten carbide-cobalt types which have recently gained better impact strength from an increase in cobalt content and have replaced the martensitic tool steels in some applications; b) chromium carbide-nickel types which have the best resistance to corrosion and oxidation; and c) titanium carbide-nickel types which have the best strength properties at higher temperatures.

Though the best known material of the last type is K162B, a recently developed compound known as X-3714, containing titanium boride and titanium carbide, appears to have better strength at temperatures in the 1800 to 2000 F range. Another recent type is a chromium-boride binary alloy, 401-S, which gives promise of being the superior cermet at these high temperatures.

3. *Nonmetallic structural materials.* These include graphite, refractory oxides, and refractory ceramics such as carbides, nitrides, silicides and borides. The oxides and ceramics have severe limitations on their ductility and impact strength and, though carrying some load, are generally used for such properties as electrical, wear resistance and insulation. However, their tolerance for varying environments and their resistance to high temperature creep have led to increasing efforts to design around their shortcomings as structural parts.

Above about 4500 F graphite has better strength properties than molybdenum and other refractory metals. It also offers extremely low density, outstanding thermal shock resistance, and high thermal conductivity. Oxidation and erosion resistance are still major problems but some progress is being made with silicide and carbide coatings. Various grades and forms are available for use in electrical, nuclear, insulation and ablation (impregnated) applications. Major high temperature structural use to date has been for nozzles of uncooled solid propellant rockets, but other uses may prove practicable.

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sion hardening. Molybdenum-rhenium alloys display low or no transition temperatures, making them both cold and hot workable, as well as stronger at higher temperatures. Sheet alloys are also under development.

Properties—Molybdenum is only about 30% denser than steel and is not as hard and brittle as tungsten. Its most outstanding property is high temperature stress-rupture strength. Notch tensile properties at high temperature are excellent. Other outstanding properties include high thermal conductivity, low thermal expansion and high elastic modulus.

The mechanical properties of molybdenum depend largely on the amount of work performed on the material below its recrystallization temperature. This is because neither the pure metal nor any of its commercial alloys are heat treatable. The properties obtained depend on many factors, including the amount of mechanical deformation, temperature of working, rate of working, strain rate and purity of the metal.

The disadvantages of molybdenum include poor oxidation resistance above 1200 F, poor impact ductility below 600 F, high density, difficulty in machining, and the tendency of welds to have limited ductility.

Fabrication—Forging of unalloyed molybdenum must be done at temperatures above 1700 F; most alloys crack if forged below 1900 F. As for machinability, not much information is currently available. In general, machinability is fair although the material is considerably more abrasive than steel at the same hardness. Pretreatments have not been effective in improving machinability.

Welds can be produced without too much difficulty resulting from porosity and cracks. However, unless it is possible to work the welded joints mechanically, the welds and heat-affected zones will have lower room temperature ductility than the parent metal. The most satisfactory welds are generally made by the inert-gas-shielded arc process using tungsten electrodes. Ductility of molybdenum is adversely affected by even small amounts of oxygen in the welding atmosphere. Resistance welding, brazing and mechanical joining can be used effectively whenever they satisfy design conditions.

How well do these materials perform?

Temperature, time and stress

Tables 4, 5, 6 and 7 on the next two pages give stress-rupture data for materials having significant strength for at least 10 hr at temperatures above 1200 F. Data are given for 10 hr (rockets), 100 hr (gas turbines), 1000 hr and, where available, for longer times that might be encountered in such commercial applications as aircraft, steam turbines and nuclear powerplants. Values for very short times of 1 hr down to a few seconds are not given because available data are extremely limited, the entire range of metals would have to be listed, and applications for these short times generally depend on properties other than stress-rupture.

No attempt has been made to list all the alloys that fall within any group of materials, but representative choices have been made. Unfortunately, except for molybdenum alloys, few data are available on the refractory alloys. For most alloys in this class, including molybdenum, stress-rupture is not usually as significant a selection factor as other properties such as oxidation. Thus, it is often the coating, not the base metal, that must be considered. A detailed discussion of coatings is beyond the scope of this manual.

Creep

Creep data are especially dependent on the rapidity of heating, holding time at temperature, and strain rate of testing. Because of the lack of standardization of tests, and because of the length of time necessary to conduct tests, creep data are less available than stress-rupture data and no attempt has been made here to present organized creep data. Nevertheless, plastic creep deformation due to both tensile and compressive stresses is a governing factor in most cases where aircraft and missile components operate at elevated temperatures, even though critical stress levels may only be encountered for a few seconds.

Where a limited amount of creep data are available for several temperatures, master plots based on referring the data to the Larson-Miller parameter can be used to predict behavior fairly accurately under other conditions. These master plots can also be extrapolated for longer time periods, though extrapolation over more than one log cycle may lead to error.

A second method of mathematically deriving creep data is to base the data on tensile stress-strain curves. At high temperatures, beyond the "knee," these curves often run almost parallel to the strain axis if closely controlled strain rates are used. When this happens it indicates that the specimen is creeping at a rate comparable to the tensile strain rate being used. Readings at several different strain rates can be obtained and a stress vs strain rate curve plotted and interpolated to give fairly broad coverage of creep rate properties.

The fact that compression creep data are not available for most materials has forced designers to use tensile creep data. Tests to date, however, indicate that this is a safe practice because creep rates in compression have been slower than those under tensile stress.

Short-time mechanical properties

Short-time tensile, yield and elongation properties are given in Table 8 for representative materials within each group.

Testing problems

As previously indicated, the entire approach to testing for high temperature use is being reexamined in the light of the extreme variations in loading, heating, service time and metallurgical behavior encountered in service today. Tests for high temperature service must be developed and standardized to take into account such factors as: loss of strength during time of heating, holding and testing; creep rate during the test; effect of varying strain rates; and effects of aging and other metallurgical changes during the test.

Of these factors, effect of creep behavior on short-time properties is particularly important. Table 9 illustrates this effect with data on one alloy. Compare tensile yield strengths for a given strain rate (such as 0.01 in./in./sec which is typical of missile loading rates) to the creep strain and rupture times under the the same load level (11,000 psi). Obviously creep deformation will occur in a few seconds and rupture in less than a minute. The value obtained from the short-time tensile test is therefore artificially high for the intended application in a sustained load structure.

On the other hand, short-time tests can underrate the material for certain applications. If service conditions require the greatest strength possible for a very short time, test results—because of heating time—will indicate a lower strength value than can be realized in service.

Nevertheless, the use of yield strength and ultimate tensile strength values can still be helpful, particularly if strain rates are carefully controlled and chosen to match the creep behavior for the time under consideration. A rapid screening of many alloys can be made from short-time values.

For example, referring to Table 9 again, a strain rate of 0.001 in./in./sec gives a yield strength of 6000 psi. This stress in creep results in 1% deformation in 12 sec. If this is the service time under consideration, some idea of the behavior of other alloys can be obtained from short-time tests at this same strain rate. However, it must be remembered that different materials have differing stress-strain curves.

Comparisons of materials

Tensile strength—Of the three superalloy groups, the nickel-base generally have the highest tensile strength. Above 1200 F the iron-base tensile strengths drop rapidly. For short-time service, the nickel alloys have higher tensile strengths than the cobalt alloys up to about 1800 F where they equalize. In general, the nickel alloys retain their strength better than the cobalt alloys for long-time service under load. Refractory metals such as the molybdenum alloys have fairly low tensile properties compared to the

Refractory alloys, *such as 90 tantalum–10 tungsten which is used in this rocket nozzle, have the best potential for use above 2000 F.*

Stauffer-Temescal Co.

10 HOURS (TABLE 4)

Stress, 1000 psi	1200 F	1350 F	1500 F	1600 F	1700 F	1800 F	2000 F
	50 (130), 23 (120)						
100	49, 17, 35	44, 50		***Key numbers refer to materials listed on page 155.***			
90	39, 1						
80	20, 8, 6, 14, 36	23	21				
70	10, 34, 30, 38, 51	49, 35, 17	37, 44, 41			26	
60	12, 42, 31, 33	39	50	21		2	
50		51, 10, 8, 14, 20, 48, 15, 12, 38	23	37, 41			26
40	13	30, 31, 33	17, 35, 51, 39, 15	50, 18, 23	21	24	
30		13, 36	9, 48, 38, 14, 8, 10, 30, 11, 31, 42, 20, 1, 12, 13, 33	51, 48, 15, 39	41, 37, 51	21	2
20				17, 20	23, 48, 14, 15, 30	41, 48, 51, 14, 23, 15	24
10					20	30, 13, 20	51, 15, 14
0							

100 HOURS (TABLE 5)

Stress, 1000 psi	1200 F	1350 F	1500 F	1600 F	1700 F	1800 F	2000 F
	41, 50, 18, 43						
100	23, 4, 49						
90	7, 16, 35	22, 37					
80	15	41, 45, 18		27		29	
70	39, 1	7, 4, 43, 50, 23, 49	32			27	
60	36, 40, 5, 10, 19, 34, 14, 9, 8, 30, 38	51, 35, 16	22				29
50	11, 31, 12, 51, 42, 33	15	41, 37, 45, 18, 50	32, 46		28	27
40	13	39, 40, 1, 9, 47, 10, 36, 5, 11, 14, 19, 38, 30	7, 23, 4	22, 26, 45, 41, 25	32	2	28
30		31, 8, 42, 12, 33, 13	39, 51, 40, 35, 15, 47, 14, 38, 16, 30	37, 18, 7, 50, 23, 51	22	26, 25, 32	26, 2
20			31, 36, 11, 9, 10, 8, 19, 12, 5, 1, 42, 33	40, 14, 47, 15, 24, 39, 12, 13, 11, 38, 30, 36	41, 37, 51, 7, 18, 23, 47, 14, 15	22, 46, 7, 45, 24, 51, 40	25, 32
10				19	11, 30, 13, 12, 19	14, 47, 50, 15, 18, 30, 19	24, 51, 15
0							

1,000 HOURS (TABLE 6)

Stress, 1000 psi	1200 F	1350 F	1500 F	1600 F	1700 F	1800 F	2000 F
100	37, 46						
90	41, 45						
80	43, 18, 50						
70	4, 23	22					
60	17, 49, 35, 16	45					
50	15, 39, 51	18, 50, 49					
40	31, 1, 14, 40, 10, 30, 34, 11, 36, 5, 9	4, 7, 23, 43, 17, 39	22			25	
30	38, 33, 8, 42, 12	51, 35, 15, 16	41, 45, 18				
20	13	40, 9, 11, 38, 31, 36, 10, 14, 30, 1, 42	7, 37, 50, 51, 23, 4, 40	46, 22, 41, 45		3	25
10		33, 12, 8, 13	39, 17, 35, 15, 30, 38, 36, 11, 14, 31, 9, 10, 16, 12	7, 51, 37, 50, 18, 23, 14, 40, 15, 36, 39	22, 51, 41, 37, 14		3
0			13, 42, 33, 1	11, 38, 30, 12, 17	18, 15, 11, 30	51, 22, 14, 39, 41, 15, 12, 13, 30	51, 15

Key numbers refer to materials listed on page 155.

Stress-Rupture Comparisons of 51 High Temperature Metals

10,000 HOURS (TABLE 7)

Stress, 1000 psi	1200 F	1350 F	1500 F	1600 F
60	50, 23			
50				
40	39	44		
30	30, 1, 33	50, 23		
20		39	44	
10		30, 33	50, 39, 23, 30	50
0			33	23, 39

KEY TO TABLES 4, 5, 6, 7[a]

Key	Material	Key	Material
1	A-286	27	Mo-0.5 Ti[d]
2	Columbium[c]	28	Mo-0.5 Ti-0.07 Zr[c]
3	Columbium[d]	29	Mo-0.5 Ti-0.07 Zr[d]
4	D 979	30	N-155
5	Discaloy	31	N-155[a]
6	Discaloy[b]	32	Nicrotung[a]
7	GMR-235[a]	33	19-9DL
8	Hastelloy B	34	Nivco
9	Hastelloy B[a]	35	Refractaloy 26
10	Hastelloy C	36	Refractaloy 70
11	Hastelloy C[a]	37	René 41
12	Hastelloy X	38	S-590
13	Hastelloy X[a]	39	S-816
14	HS-21[a]	40	S-816[a]
15	HS-25	41	1753
16	Incoloy 901	42	16-25-6
17	Inconel X	43	U-212
18	Inconel 700	44	U-500
19	Inconel 702	45	Udimet 500
20	Inconel 702[a]	46	Udimet 700
21	Inconel 713[a]	47	V-36
22	Inconel 713C[a]	48	V-36[b]
23	M-252	49	W-545
24	Molybdenum[c]	50	Waspaloy
25	Molybdenum[d]	51	X-40[a]
26	Mo-0.5 Ti[c]		

[a]Material in bar form unless otherwise indicated.
[a]Cast. [b]Sheet. [c]Annealed or recrystallized. [d]Stress relieved.

TABLE 8—SHORT-TIME MECHANICAL PROPERTIES OF SOME HIGH TEMPERATURE ALLOYS[a]

Temp, F →	Tensile Strength, 1000 psi						Yield Strength (0.2%), 1000 psi						Elongation (in 2 in.), %					
	Room	1200	1400	1500	1600	1800	Room	1200	1400	1500	1600	1800	Room	1200	1400	1500	1600	1800
IRON-BASE[b]																		
A-286	150	103	64	37	—	—	100	86	54	30	—	—	25	13	18	69	—	—
D-979	204	160	105	75	51	—	145	125	97	67	45	—	21	17	17	37	17	—
Discaloy[c]	145	109	66	36	—	—	98	83	65	35	—	—	24	15	11	18	—	—
Incoloy 901	175	138	90	70	—	—	115	88	77	60	—	—	—	—	—	—	—	—
N-155, Multimet	118	74	59	46	39	16	58	38	36	34	30	16	49	28	12	13	15	51
Refractaloy 26	154	136	108	71	48	—	91	89	90	66	47	—	19	15	13	29	49	—
Refractaloy 70	132	112	83	69	48	—	87	72	51	47	41	—	3	11	—	30	33	—
S-590	142	95	62	52	40	22	75	71	51	47	37	20	21	24	26	—	—	—
Unitemp 212	187	144	102	69	—	—	134	122	97	65	—	—	23	18	16	—	—	—
W545	175	134	80	54	—	—	125	115	70	50	—	—	20	18	34	—	—	—
16-25-6	142	90	60	47	30	18	112	75	50	37	—	—	23	12	11	9	57	59
19-9DL	118	99	45	39	18	13	69	88	40	37	—	—	55	18	36	48	56	61
NICKEL-BASE[b]																		
GMR-235	110	111	112	85	67	38	90	88	78	60	43	32	5	5	7	8	10	—
Hastelloy B[c]	131	74	68	66	53	24	56	42	40	39	39	—	50	13	12	17	11	30
Hastelloy C[c]	130	102	81	69	45	27	72	50	47	42	36	—	44	27	51	49	47	38
Hastelloy X[c]	114	83	63	52	36	21	52	39	38	37	26	17	43	37	37	33	50	39
Inconel 700[f]	171	146	120	107	84	33	104	92	88	75	56	20	25	23	12	6	7	28
Inconel 702[c, f]	141	90	76	59	33	18	84	74	70	60	32	—	36	39	4	4	26	—
Inconel 713C[f]	117	118	119	116	98	58	103	103	102	98	80	44	6	5.5	5	6	7	16
Inconel X	115	90	62	52	39	9	52	34	33	44	31	19	52	44	45	22	69	66
M-252	175	152	115	110	71	38	98	92	87	81	70	—	25	35	25	35	39	—
Nicrotung	130	120	117	115	86	67	120	111	108	102	76	52	5[d]	11[d]	5[d]	4[d]	4[d]	6[d]
Rene 41[c]	206	194	160	126	90	60	154	145	136	118	80	—	14	14	11	14	19	—
Udimet 500	175	175	135	125	85	40	110	110	105	90	72	35	15	18	21	22	22	22
Udimet 700	205	180	140	130	90	50	140	125	120	110	80	45	16	15	15	33	30	27
Waspaloy	180	163	117	100	77	35	115	100	99	90	76	—	28	33	28	28	35	—
1753	200	185	135	121	92	65	136	128	120	110	89	—	22	15	10	2.6	8.7	—
COBALT-BASE[b]																		
HS-21[c]	124	85	59	42	32	—	110	71	49	33	—	—	2	2.3	6.8	19	—	—
HS-25, L-602[c]	146	103	75	47	25	14	67	35	35	34	25	12	64	35	32	30	35	26
Nivco	165	105	—	—	—	—	110	75	—	—	—	—	25	20	—	—	—	—
S-816	140	112	73	51	25	13	70	45	40	—	—	—	35	23	22	17	20	24
V-36	146	90	51	40	29	—	67	39	38	36	27	—	55	28	17	22	32	—
X-40, HS-31[c]	128	90	63	49	29	—	113	73	44	36	—	—	2	12	14	15	31	—
REFRACTORY																		
Columbium	39.4	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—
Cb-Ta-Zr	80.3	—	—	—	—	29.6	—	—	—	39.6	—	27.4	3	—	—	4	—	2
Cb-Zr	62	—	—	—	—	—	—	—	—	—	—	—	3	—	—	—	—	—
Molybdenum																		
Stress-relieved	105	65	—	52	—	—	98	48	—	33	—	—	20	22	—	24	—	—
Recrystallized	68	34	—	25	—	—	56	11	—	8	—	—	42	57	—	60	—	—
Mo-0.5 Ti	112	70	—	62	60	58	107	70	—	60	58	55	30	11	—	14	17	22
Mo-0.5 Ti-0.07 Zr	136	112	—	100	96	88	—	—	—	—	—	—	—	—	—	—	—	—

[a]To the extent that data are available, values at high temperatures are based on treatment for highest tensile strength at each temperature indicated.

[b]Values are for wrought bar unless otherwise indicated.

[c]Sheet.

[d]Elongation in 1 in.

[e]Cast.

[f]Estimated from graph.

superalloys but retain most of their strength well over 2000 F.

Strength-weight—Strength-weight ratios are indicated for some materials in Fig 3 and 4. As a general comparison, it can be said that the iron-base superalloys have fairly high strength-weight ratios. Fortunately, the addition of such elements as titanium and aluminum to the nickel superalloys for the purpose of increasing high temperature strength also lowers density and improves strength-weight ratios. The cobalt superalloys, on the other hand, are strengthened by additions of tungsten and molybdenum—elements that increase density.

TABLE 9—TENSILE AND CREEP PROPERTIES OF N-155 AT 2100 F

Tensile Properties			Creep Rate and Rupture Times				
Strain Rate, in./in./sec	Yld Str, 1000 psi	Ten Str, 1000 psi	Stress, psi	Time to Creep, sec			Time to Rupture, sec
				½%	1%	2%	
0.0001	2.5	—	3000	130	320	700	900+
0.001	6.0	—	4000	35	80	170	780
0.01	11.0	11.0	5000	12	26	54	410
0.20	—	16.0	6000	5.5	12	24	225
			7000	2.6	5.1	10	93
			8000	1.4	2.6	5.0	75

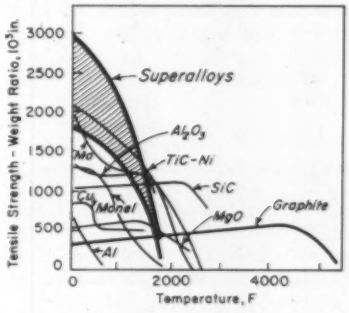
TABLE 10—THERMAL PROPERTIES OF SOME HIGH TEMPERATURE ALLOYS

Alloy	Avg Melt Pt, F	Ther Cond, Btu/hr/sq ft/°F/ft*	Coef of Ther Exp, 10^{-6} per °F*
IRON-BASE		1200 F	70-1500 F
A-286	2550	14.3	10.3
Discaloy	2500	13.0	9.6
N-155, Multimet	2410	12.8	9.8
Unitemp 212	2480	13.7	10.0
W545	2480	10.7	9.7
19-9DL	2590	12.2	10.0
NICKEL-BASE		1600 F	70-1600 F
Inconel 700	—	10.5	9.27
Inconel X	2570	15.0	9.2
Rene 41	—	14.6	8.7
Udimet 500	—	14.1	9.0
Waspaloy	2450	14.6	9.1
COBALT-BASE		1300F	70-1500 F
HS-25, L-602	2450	13.1	8.9
Nivco	1650	17.2	8.1
S-816	2400	13.0	7.8
REFRACTORY		1600 F	32-1600 F
Molybdenum	4720	60	3.2
Mo-0.5 Ti	4760	58	—

*At temperature or in temperature range indicated for each group of alloys.

The refractory metals as a group are characterized by rather low strength-weight ratios, with chromium and columbium rating higher than the others. However, data are limited and alloys for fair comparison have yet to be developed.

Consideration of strength-weight ratios would not be complete without mention of the borderline material, graphite, which has the highest ratio of all materials above 2500 F. The curve for graphite is given in Fig 3.

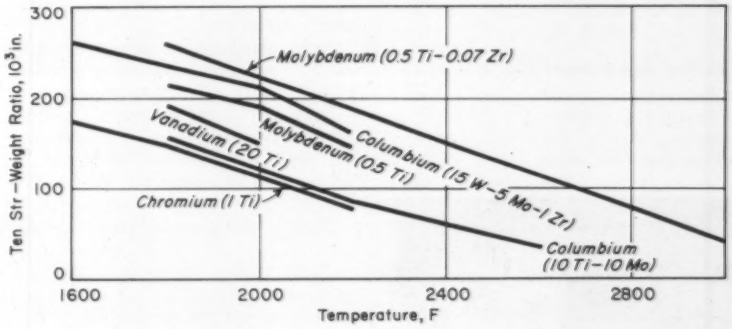


3 Strength-weight ratios *of superalloys compared with those of ceramics, graphite and some other metals.*

Thermal properties

Standard thermal physical properties are given in Table 10 for alloys in each of the materials groups discussed. Most of the superalloys are austenitic and exhibit about the same thermal expansion and thermal conductivity. In general, values of these properties are lower for superalloys than for stainless steels, although the iron-base group suffers from slightly higher thermal expansions. Low thermal expansion is a design advantage and also offers greater buckling resistance. High thermal conductivity is an advantage in high temperature applications and also makes welding easier. Molybdenum, in the refractory group, has high thermal conductivity and low thermal expansion.

As for thermal shock, data for most materials are unavailable. However, few materials have high thermal resistance to shock and fatigue. The tougher, more ductile materials warp; the stronger, harder materials crack. Among the superalloys there is some indication that the cobalt-base materials have the best thermal shock and cycling resistance, followed by the solid solution type of nickel and iron-base alloys. Wrought materials can generally withstand thermal stress better than castings.



4 Strength-weight ratios *of refractory alloys.* (Battelle Memorial Inst.)

Oxidation resistance

Individual alloys differ widely in their ability to resist oxidation. In general, the superalloys have good oxidation resistance to about 2000 F, at least for times of 100 hr or less, with the nickel-base group considered somewhat superior to the others. Additions of chromium and controlled amounts of molybdenum further increase oxidation resistance, particularly of the nickel-base alloys. As indicated before, the refractory alloys have severe oxidation problems at higher temperatures.

Scaling and corrosion are a matter of temperature, environment and time. In the jet and rocket fields the nature of the corrosive hot combustion gases is particularly important. Alloys with increasing chromium content (up to 25%) have good resistance to scaling at up to 2200 F.

Other ways to solve high temperature problems

The bulk of this manual has been devoted to the selection and use of commercially available materials, based on their properties and relying on standard methods of treatment and fabrication. This is the immediate, practical approach that naturally appeals to engineers pressed for time and limited in facilities who must recommend a material, process and fabricating sequence now—not several months or several years from now.

However, the problems posed by today's high temperature applications are being attacked on many fronts. It is well to be aware of these other approaches. Although they are outside the scope of this manual, the following sections give some idea of the nature of each of these other nine approaches to the problem.

1. Materials research

Basic studies on the nature of materials. Such work, for example, could result in ways to make ceramics and cermets ductile, or could result in new ways—such as oxide dispersions—to "peg" the slip planes in metals and thus reduce creep.

2. Materials development

Alloying research and development work is proceeding at a rapid rate today, from the standpoint of both major alloys and minor alloying additions.

For example, it has been found that relatively small additions (less than 1%) of titanium, or other metals such as zirconium and hafnium, result in relatively large increases in high temperature strength. Also, there is an interaction between titanium and the approximately 0.03% carbon impurity. Greater creep strengths have been obtained by adjusting the relative proportions of these two minor elements.

Processing behavior can also be improved by alloying. For instance, relatively large amounts of rhenium (25-35%) added to molybdenum as it is arc cast result in ingots that can be hot worked directly without initial extrusion to break down the cast form. The rhenium causes the formation of a nonwetting complex oxide that does not concentrate at the small grain boundary areas of the cast ingot.

***Testing equipment** like unit below is necessary to obtain accurate high-temperature mechanical properties. Loading, strain rates and temperature must be closely controlled.*

Battelle Memorial Inst.

3. Materials Production

New ways of producing materials make it possible to obtain more advantageous compositions and more useful forms.

Electron beam melting, for example, makes it possible to produce higher purity refractory metals such as tantalum and columbium. High purity increases room termperature ductility. The process is being investigated for some of the superalloys.

Rolling molybdenum sheet is difficult because of the excessive scaling that occurs. One solution is inert-atmosphere working such as is done in the argon-filled room at Universal Cyclops Steel Corp. where workers wear high altitude oxygen equipment.

4. Materials treatment

Strengthening treatments such as heat treating, age hardening and work hardening are often limited to moderate temperatures due to the structural instability of many high temperature alloys at temperatures close to critical ranges such as transformation, aging and recrystallization. Close study of each alloy is needed so that optimum heat treatments can be developed for various fabricating and service conditions.

5. Materials fabrication

New hot working techniques are being developed for recalcitrant materials. Tungsten, for example, is now being fabricated by pressing, spinning, extruding and forging. These operations are possible because of new techniques which use high temperatures, high rates of deformation, and high speed equipment such as hydraulic presses, rolling mills and spinning lathes. Explosive forming, of course, is the most spectacular of the new high-deformation-rate techniques.

Rapid progress is being made in welding. Equipment and techniques for such welding operations as electron beam, ultrasonic and capacitor-discharge are being developed for many difficult-to-weld materials (see "The New Welding Processes," M/DE, Jan '60 p 105).

6. Materials testing

The need for standardized tests giving data that will accurately predict behavior under service conditions is discussed earlier in this manual.

7. Materials design

An outstanding example of what can be accomplished is the now-familiar honeycomb structure. Webbed, double-walled, clad and laminated materials are other approaches.

8. Component design

This, of course, is a matter of suiting the design to the application. A great amount of thought is being given to the development of thermally nonredundant structures which are designed to compensate for thermally induced physical and mechanical property changes. Another design approach is the use of regenerative cooling in gas turbines, an approach that might be considered as another example of the thermal accomodation approach (below).

9. Thermal accommodation

This term refers to those techniques being used and investigated today which isolate structural materials from the environmental temperature. Other classes of materials, such as reinforced plastics, are involved, and the system depends largely on their physical and chemical properties. This approach may be divided into five methods: 1) conduction (heat sink), 2) convection (transpiration and/or film cooling), 3) radiation and reflection, 4) insulation and ablation, 5) physical and chemical state change. This subject will be discussed in a future issue.

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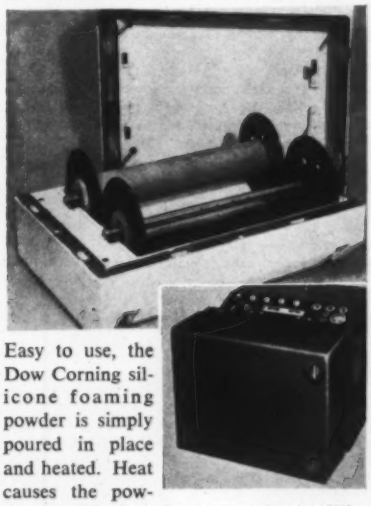
A FOAMED-IN-PLACE SILICONE PROTECTION

Engineers at Consolidated Electrodynamics Corporation have found a foam-in-place silicone resin ideal for protecting the magazines of oscillographs used to gather vital data during dynamic testing studies of variables affecting aircraft performance.

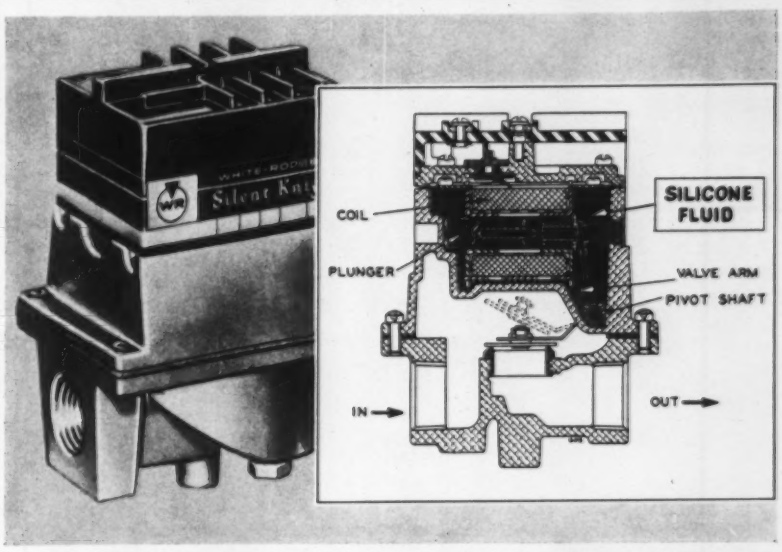
CEC's Recording Oscillographs are capable of simultaneously making permanent, photographic records of up to 50 factors affecting performance. These instruments record information in terms of electric current and catalog all phenomena in true relation to time and to one another.

To be certain that these critical data will be preserved for study through all eventualities, even when experimental aircraft must be ditched, CEC designed and built the first effective crash-resistant storage magazine. The magazine is housed in a ductile-iron casting surrounded by a stainless steel shell. It's protected against heat and shock by a silicone resin foam that fills the space between casting and shell.



Easy to use, the Dow Corning silicone foaming powder is simply poured in place and heated. Heat causes the powder to melt and foam, completely filling the void. Additional protection is provided by painting the outer steel shell with a fire resistant paint that foams at 300 F.

How effective is the Dow Corning silicone foam? CEC estimates the magazine will withstand a shock of 400-g's followed by a fire as hot as 2,000 F! In addition, the magazine is explosion-proofed in accordance with MIL-E-5400 A (ASG). *No. 241*



SILENCES GAS VALVES

Use of silicone fluid has enabled White-Rodgers Company, St. Louis, to produce gas valves that give completely silent service on such units as central heating, floor and wall furnaces, conversion burners, boilers, unit heaters and room circulators. Here's how:

White-Rodgers' engineers effectively eliminated operating noises by immersing the entire operating mechanism of the new Silent Knight Gas Valves in Dow Corning 200 Fluid. Enclosed in an unbreakable metal case, the viscous fluid slows the mechanism, cushions the components and makes them silent. Eliminated are the characteristic "snap" of the relay, the "hammering" of the plunger. In addition, by damping the opening action of the valve, some of the undesirable "pop" of the gas ignition is eliminated.

Silicone fluid proved the ideal damping medium because it doesn't thicken or thin with temperature changes, thus assuring consistent, uniform damping far beyond the capabilities of previously available damping oils. This fluid's noncorrosiveness and resistance to oxidation and to breakdown under shear assures long-time reliable service.

What's more, Dow Corning 200 Fluid's remarkable thermal stability helped simplify the design and increased the reliability of the gas valve by eliminating the need for rubber diaphragms or bellows in the fluid chamber. *No. 242*

THE BETTER TO "SEE" WITH...SILICON

Optical silicon, now available from Dow Corning, enables infrared surveillance and detection devices to home on heat waves . . . to put missiles on target.

Crystalline ingots, domes, prisms and flats produced by Dow Corning for such use are held to less than two parts impurity per 100 million. Infrared optics attained by proper grinding, polishing and coating of optical silicon provide more than 95% transmission of a signal of any desired wavelength between 1.3 and 6.7 microns, have excellent light gathering power.

Dow Corning optical silicon crystals show excellent heat stability and shock resistance. Their abrasion resistance, chemical stability, light weight and strength are other desirable features. *No. 243*

PROPERTIES OF DOW CORNING OPTICAL SILICON

Melting point	1420 C
Hardness	7 Moh
	1150 Knoop
Thermal conductivity	0.39 cal/cm-sec-°C
Thermal expansion	4.15 x 10^{-6}/C°
Flexural strength	20,000 psi

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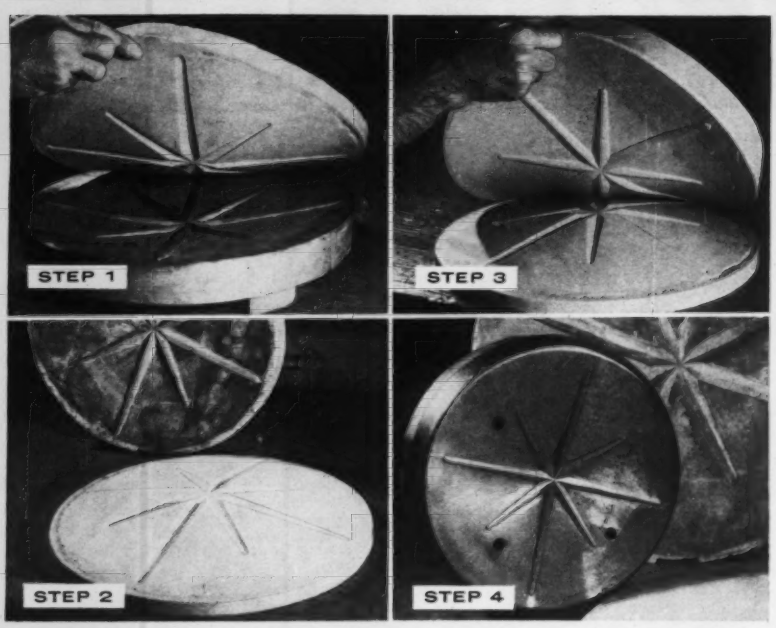
MORE



HOW TO MAKE PROTOTYPES

Silastic® RTV provides a new and better way to make prototypes. Here's how one automotive parts supplier — Cadillac Stamp Company, Detroit — uses this Dow Corning room-temperature-vulcanizing silicone rubber to make templates for hubcap embossing dies.

STEP 1. Silastic RTV is poured onto a wood pattern machined to the exact configuration of the hubcap design. With its fluid consistency, Silastic RTV flows into and around complex shapes and intricate and deep draws—then vulcanizes at room temperature to produce a strikingly accurate "negative" mold.

STEP 2. A plastic "positive" of the original pattern is then cast in the Silastic RTV mold. This "positive" forms a prototype from which a pantograph-type engraving machine can sink female dies.

STEP 3. Next, more Silastic RTV is poured into the original silicone rubber "negative" mold made of Silastic RTV to form another RTV "positive". After this new charge has vulcanized in the mold the two are separated. Coating the mold with a release agent facilitates clean and quick separation of the new "positive".

STEP 4. A plastic form is now cast from the Silastic RTV "positive". This plastic template is used in guiding the engraving machine in producing male sink dies. In this process, size is reduced by one-half.

An economy feature: Thanks to Silastic RTV both embossing dies are made from one wood original.

For more information, circle . . . *No. 244*

NEW ENGINEERING GUIDE

A 16-page compilation of information on properties and applications of silicones used by design and production engineers in all fields. To obtain your complimentary copy, circle *No. 245*

See how silicones can help you! See how you can use them to advantage in virtually every industry.

Dow Corning movies, that are yours for the asking, portray the roles different forms of silicones play in different engineering and design applications.

Each is a 16 mm, full color, sound movie. Each is available at no charge for showing to your engineering group.

To learn more about arranging for a showing of any of the movies described below, circle the corresponding number on the coupon or reader service card.

You And The Silicones — This 30 minute documentary film depicts the story of silicones in dramatic full color. Shown are their versatile forms, unique properties, and countless applications in bakeries, power plants, dairies, chemical plants, shops, automobiles, jet planes and missiles, and even in the kitchen and swimming pool. This movie shows how silicones have made possible new designs and changes in equipment for industry, home, and military . . . . *No. 246*

Rubber From Rock — See for yourself how Silastic, the Dow Corning silicone rubber, is made . . . how it is used to make good products better, from aircraft to nursing bottles. See how parts made of Silastic stay flexible over a wide temperature span; withstand long exposure to ozone, corona and weathering; remain dielectric materials after exposure to flame at 2000 F. A complete visual story about Silastic . . . *No. 247*

Silastic RTV — In just 14 minutes, you can see the entire story of this ready-to-use fluid silicone rubber that effectively resists weathering, moisture, oxidation, shock and vibration. Learn how effectively and quickly you can make prototype molds and parts. The versatility of this room temperature vulcanizing rubber is limited only by a designer's imagination. See RTV in use. *No. 248*

More Muscles For Tomorrow — The story of silicone electrical insulation is told in this full color, sound movie. It explains how you can increase life and reliability, attain up to 50% greater service factor in electric equipment systems insulated with Dow Corning Silicones. See how silicone insulation contributes to greater miniaturization, increases power per pound ratio . . . cuts maintenance and downtime. *No. 249*

Dow Corning Corporation, Dept. 5306, Midland, Michigan

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MATERIALS AT WORK

...AT A GLANCE

Glass-reinforced ice may be the igloo material of the future. Current research on the use of ice as a structural building material has led some scientists to believe that this "most plentiful and so far least useful" substance on earth may provide the cheap, strong building materials necessary for the development of the vast wealth of the arctic and antarctic regions. According to the scientists, ice can be thought of as a metal that melts at about 32 F. And although it is pretty weak in its natural state—tensile strength is about 200 psi—the addition of glass fibers increases its strength to about 2000 psi.

Source: Massachusetts Institute of Technology, Ice Research Laboratory.

Forged aluminum track shoes may replace steel on military tanks. The 2014-T6 aluminum forgings were subjected to severe tests and gave every indication of meeting all requirements previously set for steel. The major advantage offered by aluminum is reduced weight: each of the forgings weighs about 3½ lb less than the comparable steel part. A medium tank uses about 320 shoes—total weight reduction of over 1000 lb.

Source: Kaiser Aluminum & Chemical Corp.

Nylon cushions are being used to recover tactical missiles during training and test flights. Two of the neoprene-coated cushions, which are shaped like giant sausages and used as "shock absorbers," are strapped around the belly of the missile. When the "ground pilot" controlling the missile by radar desires to bring it back, he throttles the jet engine to about 60% power, ejects a drag parachute and initiates an air compressor which inflates the two cushions. The inflated cushions absorb enough of the landing shock to completely protect the missile.

Source: Goodyear Tire & Rubber Co.

Lead, concrete, water and polyethylene are combined in an extremely effective radiation shield aboard the atomic-powered ship, N. S. Savannah. A major design problem was to provide proper radiation shielding without adding too greatly to the weight and bulk of the 20,000-ton vessel. The radiation shield is divided into two parts. The first, which surrounds the nuclear reactor and is designed primarily to slow down and stop neutrons, consists of a 33-in. thick shell of water lined with approximately 3 in. of lead. The second, which surrounds the entire containment vessel, is composed of a concrete wall and a polyethylene-covered, 4-8 in. thick shell of lead.

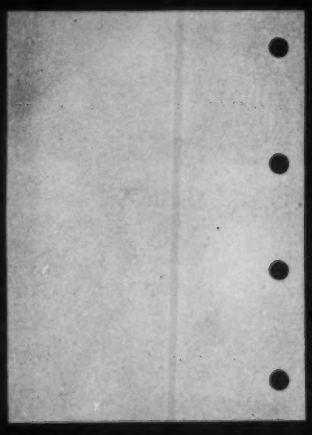
Source: Lead Industries Assn.

The switch from bronze to a laminated plastic gear has resulted in increased life, lighter weight and reduced cost. The plastics gear, used in a home floor polisher, is said to last at least five times longer than the bronze gear, weigh only one-sixth as much and cost about 20% less. In addition, it has excellent machining characteristics and runs more quietly than the bronze gear.

Source: Spaulding Fibre Co., Inc.

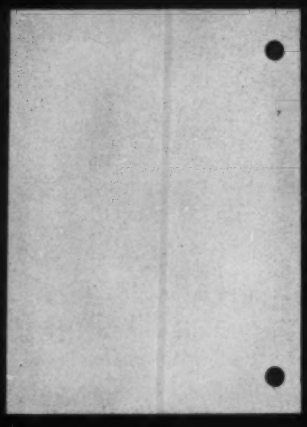
Ferro ONE-COAT Porcelain enamels

for "special" and non-premium steels

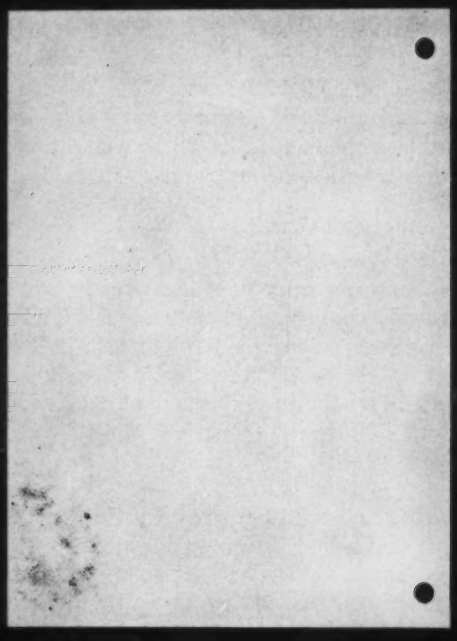


SPECIAL STEEL "A" (Armco Steel)

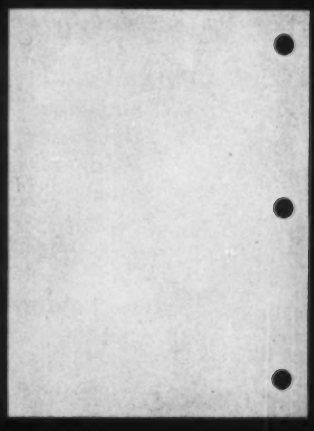
SPECIAL STEEL "C" (Inland Tinamel)



SPECIAL STEEL "B" (Bethlehem Steel)



REGULAR COLD-ROLLED, RIMMED STEEL



SPECIAL STEEL "D" (U. S. Steel)

What is Best for your products?

See and compare the fine *one-coat* porcelain enamel finishes developed by Ferro over the past ten years. They may be used with a variety of steels, as shown above, each of which has been thoroughly tested if not already in commercial production. While processing techniques may differ, any one of these steels can be used to obtain a high-quality porcelain enamel finish with *one-coat* at substantial savings.

Ferro's most recent process, widely publicized in recent months, makes possible the use of *non-premium* steels for these superior one-coat finishes. This, of course, means lower material costs and wider sources of steel supply.

Whichever base metal *you* may select, you will find Ferro's experience and production-proved products extremely valuable in adapting *one-coat* porcelain enamels to your products, your production facilities. When can we talk to you about it?

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Completely assembled *Winchester 59 shotgun with glass fiber barrel weighs only 6½ lb.*

Radically New Shotgun Barrel Is Made of Epoxy-Impregnated Glass Fiber

■ Dramatic improvements in performance are provided by a new lightweight barrel for the Winchester Model 59 semi-automatic shotgun. The new barrel, called the Win-Lite, consists of two main elements: a thin, inner steel tube, and an outer structural shell of epoxy-impregnated glass fibers. Developed after five years of research, the new design is claimed to be the first innovation in barrel design in half a century.

Four important advantages

According to the shotgun manufacturer, Winchester-Western Div. of Olin Mathieson Chemical Corp., New Haven, Conn., the technological breakthrough in use of materials will provide sportsman with four major advantages:

1. Durability. The barrel and receiver cannot rust or rot and are not affected by exposure to weather.

2. Greater safety factor. Rigorous tests indicate that bore obstructions sufficient to bulge or burst a good steel barrel will only cause a slight ring in the glass fiber barrel and will not impair its shooting characteristics.

3. Cooler shooting. The heat absorbing properties of the glass fiber barrel eliminate hot barrels and heat distortion, thereby making a ventilated rib unnecessary. Furthermore, low temperatures do not affect the barrel and it can be handled with bare hands at 40 degrees below zero without sticking.

4. Lighter weight. The gun—which has an aluminum receiver—weighs less than 6½ lb. This permits faster pointing and reduces fatigue.

1 [2] [3] 4 5 6 7 8 9

Barrel components *at different stages of manufacture and assembly:* **1** *threaded end section;* **2** *cylindrical barrel liners;* **3** *threaded end sections and barrel liners assembled;* **4** *barrel after being wound with glass fiber filaments;* **5** *after wrapping with glass fiber cloth;* **6** *after impregnation;* **7** *after grinding;* **8** *after placement of holding lug; and* **9** *after final painting.*

How it is made

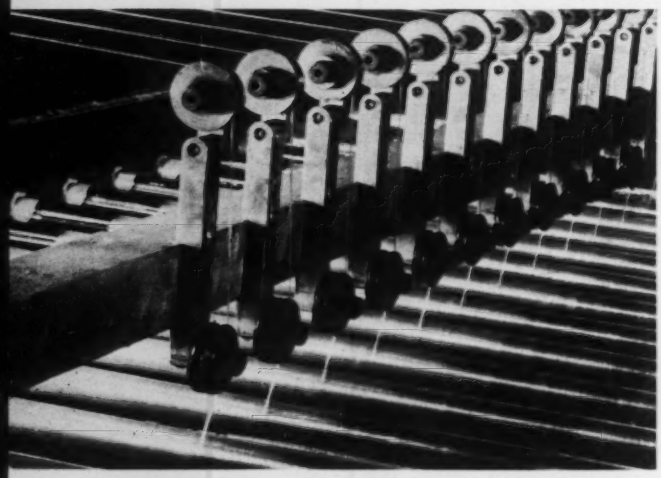
Inner structure of the barrel consists of two metal sections—a 0.02-in. cylinder liner made from seamless drawn tubing, and a cylindrical threaded end section of chromium-molybdenum steel which joins the barrel to the gun action.

Following assembly, these two metal cylinders are wound with 10 ends of size 150 1/0 strands of glass fiber filament treated with a compatible epoxy finish. The fila-

ments are pulled (see photos) from a creel under controlled tension and wound by rotation of the barrels.

The barrel is oven cured after winding and then lightly sanded to perfect its contour and to provide a rough surface for a subsequent wrapping of glass fiber cloth. This cloth is wrapped so that the lengthwise fibers are parallel to the barrel axis. The barrel is then oven dried and impregnated with an epoxy formulation applied under relatively high vacuum.

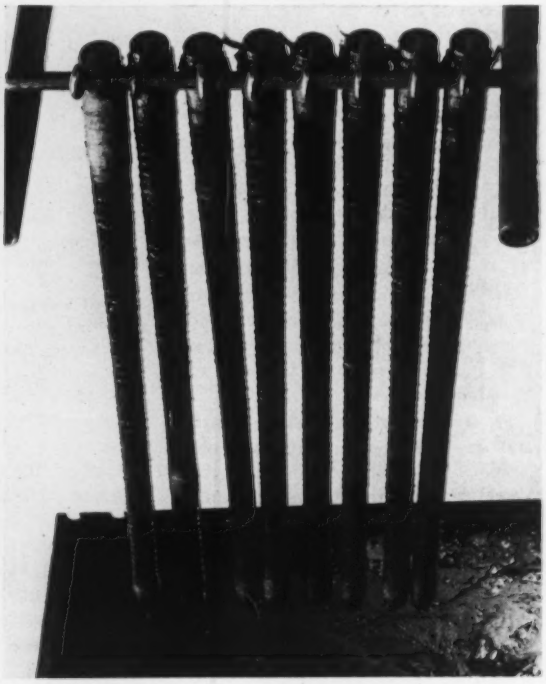
After air drying, the barrel is ground to its finished contour. At this point the holding lug and front sight are bonded on with a heat-curing epoxy adhesive. The barrel is then ready for its final finish—a prime coat and a baked, epoxy topcoat.



Filament winding *is done on 12 barrels at a time.*

Sanding operation *is necessary after winding to give barrels right contour and to roughen surface prior to wrapping with glass fiber cloth.*

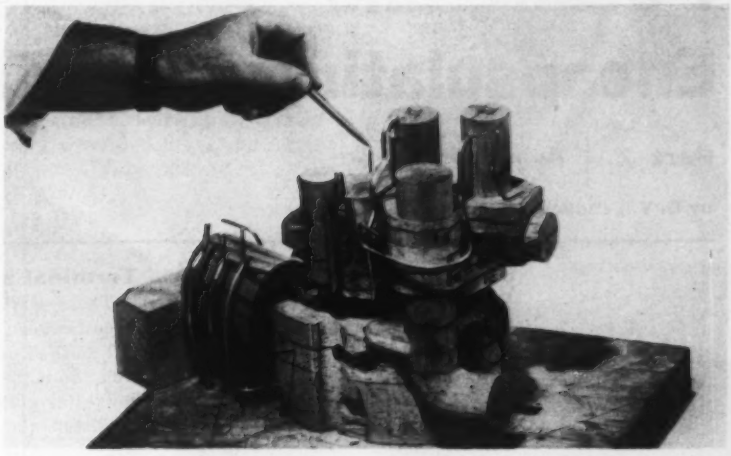
Vacuum impregnation *with epoxy resin is performed on 32 barrels at a time.*

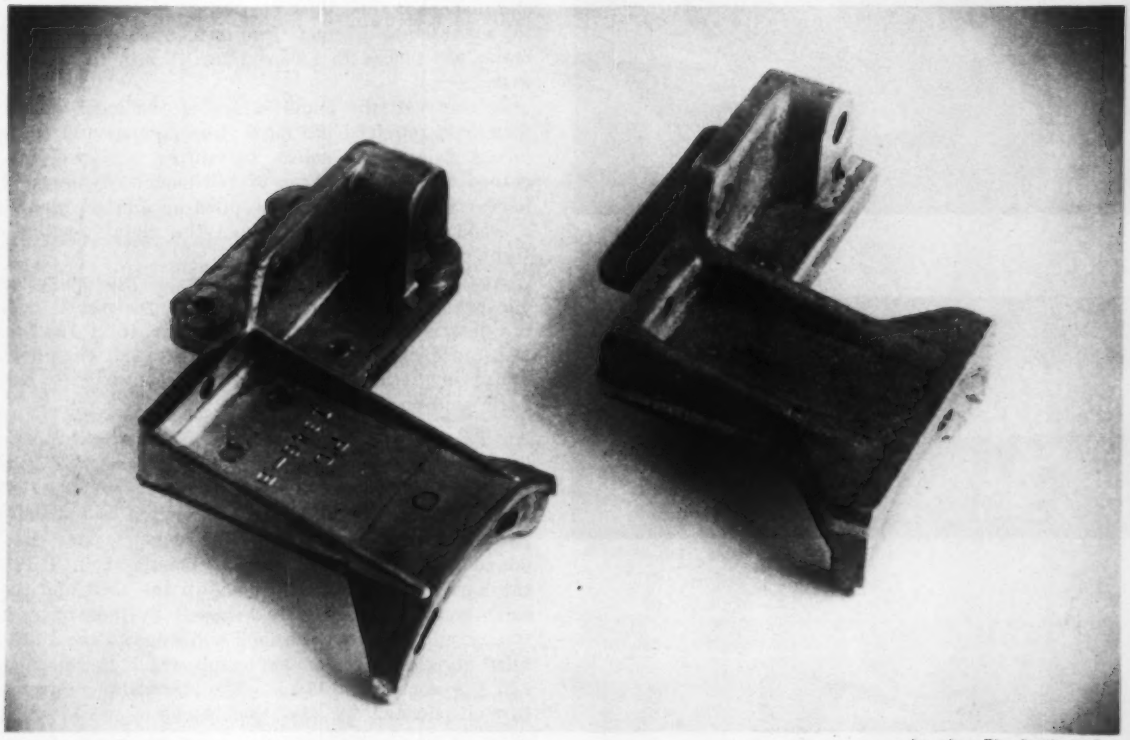


After impregnation *barrels are air dried, ground to final shape, and then coated with epoxy paint.*

Tubing Sheathed with Stainless Braid Used to Core Magnesium Castings

Copper tube sheathed by stainless steel braid can serve as coring material when magnesium castings require intricate internal passages such as those shown by the wooden model mold (right). Organically bonded cores are unsatisfactory because they produce gases. The problem with metal tube cores is that they must be dissolved out without affecting the magnesium. Howard Foundry Co. pulled stainless steel braid (0.0036-in. type 304 produced by National Standard Co.) over copper tube to form the coring material. After casting, the copper is dissolved with acid and the braid pulled out.





American Zinc Institute, Inc.

Bracket Cost Cut 75%

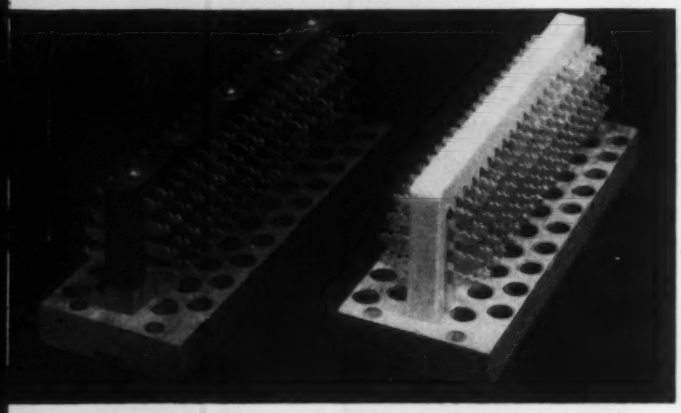
The zinc die cast mounting bracket shown above replaced an aluminum sand casting (right) with production savings of 75%. In addition to a considerable reduction in secondary machining operations, the change to zinc resulted in higher tensile strength, thinner walls, and a smoother surface.

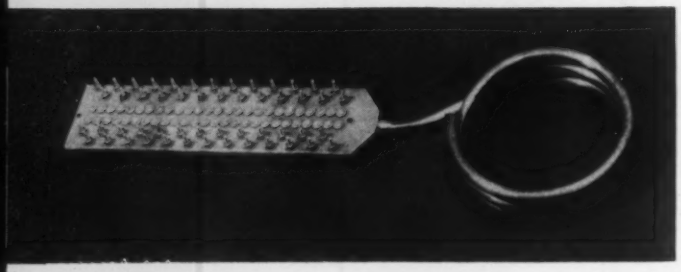
A Guide to Potting and Encapsulating Materials

Part 2. | Applications

by C. V. Lundberg, *Bell Telephone Laboratories*

1. Styrene-polyesters





Terminal strip

These contrasting parts show the marked difference between an electrical terminal strip made by an old method using machined hard rubber strips (left) and the same strip made by casting a filled styrene-polyester compound.

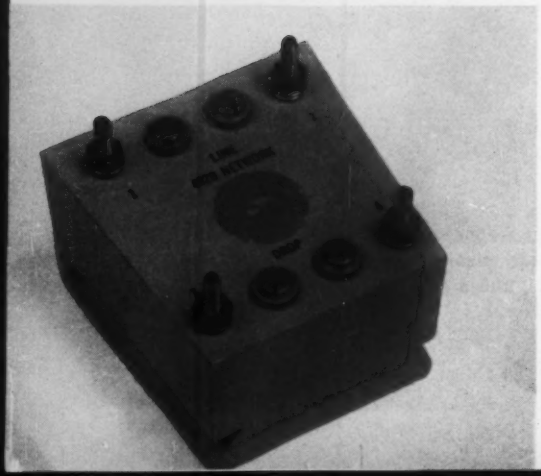
Encapsulation permits the assembly to be made in a few simple steps. First, the silica and glass fiber fillers are mixed with the base styrene-polyester resin by ball milling. Second, the mixture is catalyzed and dispensed through a nozzle into molds containing the preassembled finger terminals. Finally, the filled molds are placed in an oven for 45 min to gel and cure.

In contrast, the manufacture of the hard rubber terminals required the hard rubber compound to be mixed, calendered, rolled, vulcanized, stripped, machined and slotted. Five of the machined pieces of hard rubber then had to be piled up and screwed to a wood base in order to hold the metal terminals tight.

An added advantage of the styrene-polyester encapsulant is that its insulation resistance does not deteriorate with time. Previously, the insulation resistance of the hard rubber decreased when free sulfur in the material oxidized and converted to sulfuric acid on exposure to moisture.

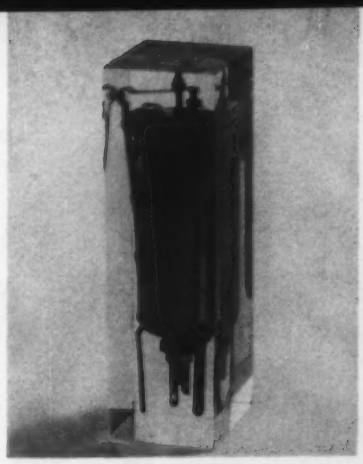
Cable terminal

This neat, functional, cable terminal is made by potting the hardware with a styrene-polyester compound in a styrene-acrylonitrile plastic shell. First, the hardware is bolted in place in the shell and the cable conductors are wire-wrapped on their respective terminals. Next the shell is filled with the silica-filled styrene-polyester compound which is gelled at 125 F and cured at 170 F. The processing temperature is limited by the thermoplastic shell which deforms at temperatures over 200 F.



Electrical network

A silica-filled styrene-polyester is used to encapsulate this 3 × 3⅜ × 2-in. electrical network. In addition to its good electrical properties the silica-filled material provides good protection against mechanical shock, vibration and abuse. Typical heat treatment for the material cast in this size: a 30-min gel at 125 F followed by a 1-hr cure at 250 F.

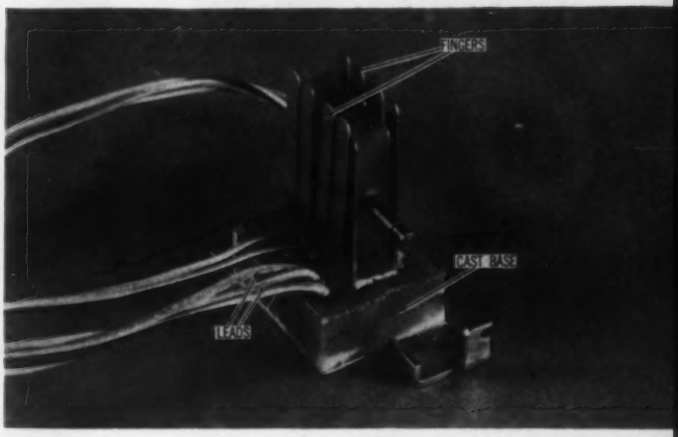


Electronic display

Transparent styrene-polyesters lend themselves beautifully to the encapsulation of electronic assemblies for display and preservation purposes. Shown here is a desk specimen made from a clear, rigid styrene-polyester which has been slowly gelled over several hours at moderate temperatures so as to minimize strains and avoid cracking.

Telephone switch

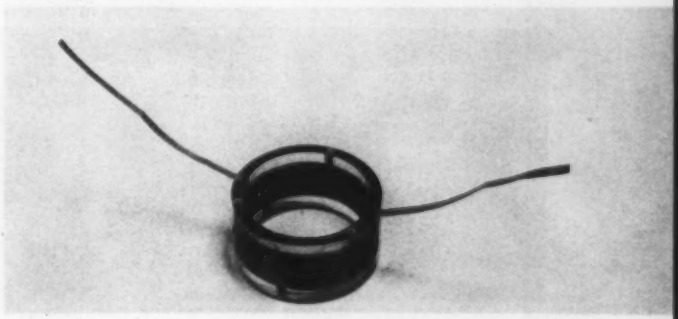
This pre-production model of a compact telephone switch contains 16 phosphor bronze fingers, 3 plastics spacers and 8 insulated wire leads, all held together by a cast, silica-filled styrene-polyester material. This is an excellent example of the use of the casting technique; pressure molding could not be used since the pressures involved would displace and distort the fingers, wire and plastics inserts. Dimensions of the castings are only 11/16 × 7/8 × 1/4 in. In small castings such as this, exothermic heat is not a problem and the resin may be gelled and cured at 225 F in a matter of minutes.



2. Epoxies

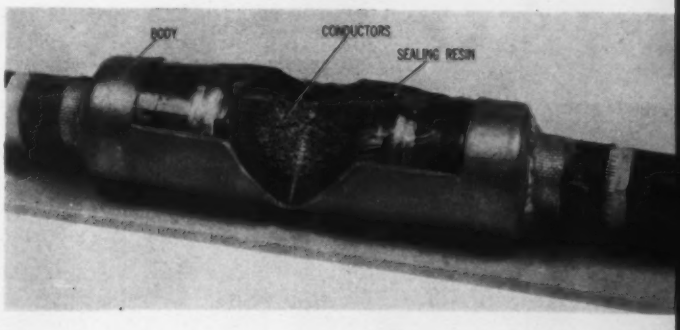
Hydrophone coil

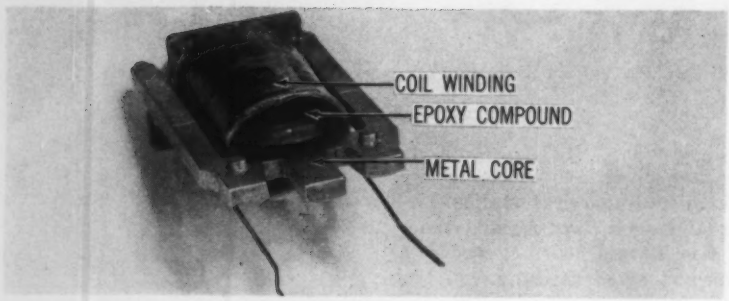
Epoxy encapsulants are particularly noted for their excellent adhesion and low shrinkage. Shown here is a hydrophone coil which has been impregnated and encapsulated with a clear, rigid epoxy. In spite of its rigidity, the epoxy material still retains sufficient elasticity so that on removal of an axial load equivalent to 10,000 psi, it returns to within 5 mils of its original height without fracturing. The maximum deformation encountered is 1/32 in.—approximately equal to 4% of the coil's original height.



Cable plug

This cutaway view shows a potted cable plug which forms a gastight seal so that the cable on one side of the plug can be maintained under gas pressure. (Gas pressure in the pressurized cable maintains electrical properties by preventing rain or moisture from entering the cable through cracks developed in the sheath during aging.) Sealing action is obtained by pouring or forcing a flexibilized liquid epoxy resin into the plug volume. The resin penetrates between the conductors, wets the paper insulation, and cures within several hours into a solid resilient mass.

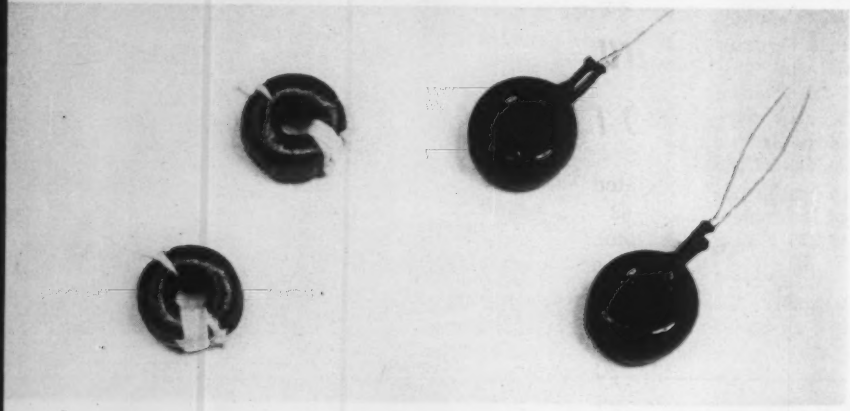




Relay

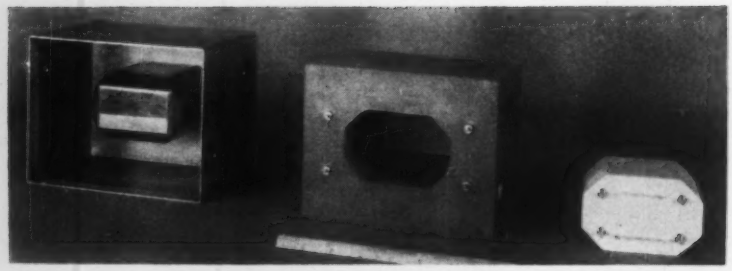
Here is an unusual and interesting application of a silica-filled epoxy compound in a wire-spring relay. The epoxy compound is cast between the coil winding and its metal core, and transmits heat from the coil to the core. Thus, the coil and its insulation can operate at a lower temperature.

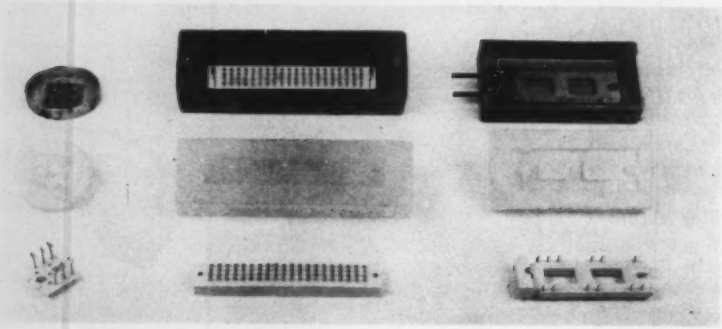
3. Plastisols and wax



Toroidal coils

Delicate components such as these toroidal coils have much greater resistance to mechanical abuse when encapsulated. Coils at left have been given a conventional wax impregnation; coils at right are thoroughly protected with a thick polyvinyl chloride plastisol coating which solidifies in about 10 min at 300 F. The vinyl coating shows no serious change in properties when aged in normal atmospheres.





Molds

Vinyl plastisols (as well as silicone rubber) are also extremely useful for molds to contain cast epoxy encapsulating materials. Shown at the top is a polished metal master for making the plastisol mold, the plastisol mold itself, and an epoxy encapsulated transformer which was cast in the plastisol mold. The mold was converted from a liquid to a rubbery solid by heating at 325 F.

Shown at the bottom are three other interesting examples where plastisol molds were used to form epoxy encapsulated components. Such molds are particularly useful for casting development models and limited production parts.

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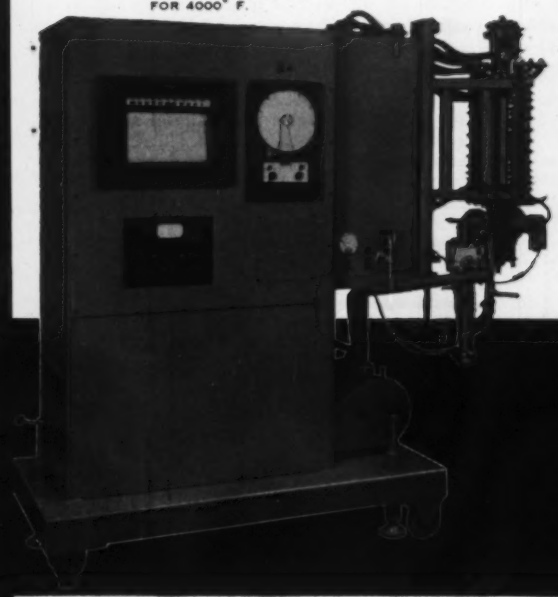

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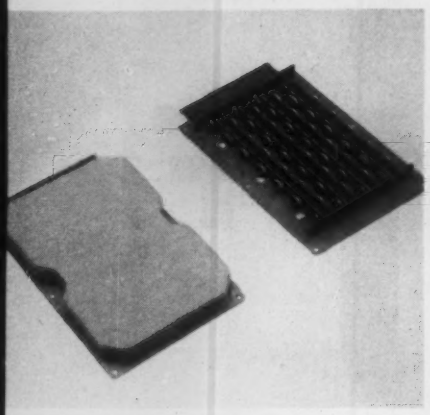
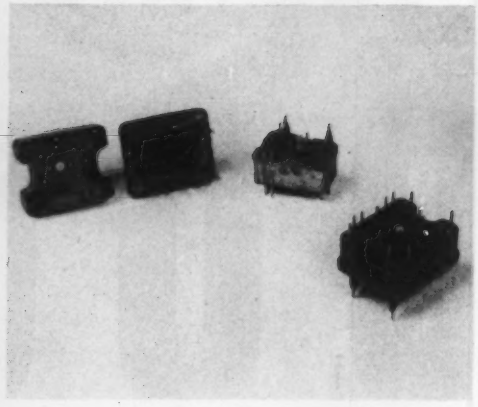
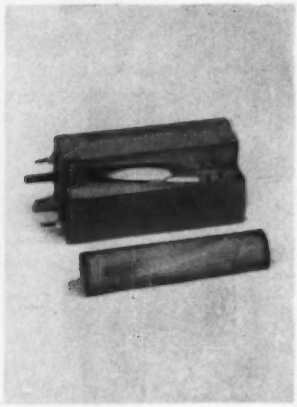
4. Foams

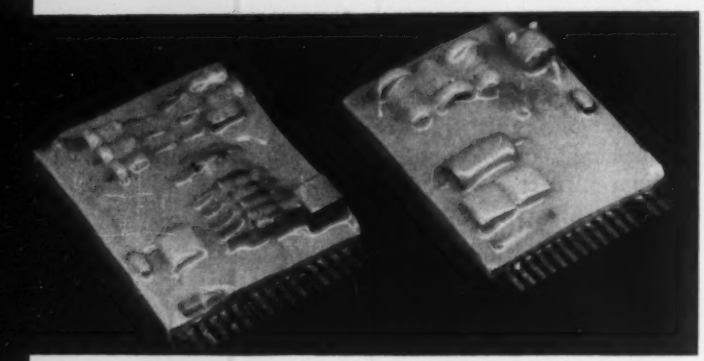






Networks

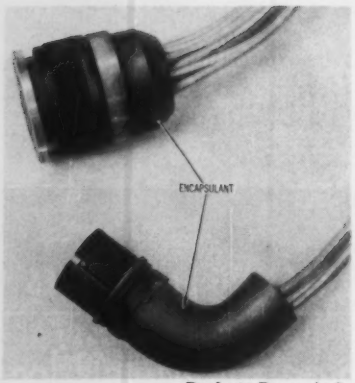
Rigid polyurethane encapsulants are especially valuable because of their light weight and ability to "ruggedize" components and prevent their movement during severe impact and vibration. Shown at the left is a delay line network after and before encapsulation in rigid polyurethane foam. This foam was also used to encapsulate the networks in the other photos. Of especial note in the middle photo is that the containers are made of both metal and plastic. The one-shot foams used in these applications have a density of 10 lb per cu ft and weigh only 11% as much as conventional silica-filled, rigid compounds.



5. Elastomers

Printed circuits

These printed circuits are given a thick undercoat of silicone rubber to protect them against the shrinkage effects of rigid encapsulants. The flexible coating not only prevents mechanical damage to the components as the encapsulant shrinks, but reduces changes in electrical properties caused by shrinkage. In addition, the coating reduces the tendency of the rigid encapsulant to crack during extreme temperature cycling, and reduces or overcomes any tendency of the board to warp when the volume of rigid encapsulant is greater on one side of the board than on the other.



Products Research Co.

Cable connectors

The good sealing properties and flexibility of polysulfide rubber compounds are especially useful in encapsulating cable connectors. Flexibility is especially important in the bottom multi-terminal connector because of its right angle bend.

MORE MATERIALS AT WORK

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Formed vinyl props 172

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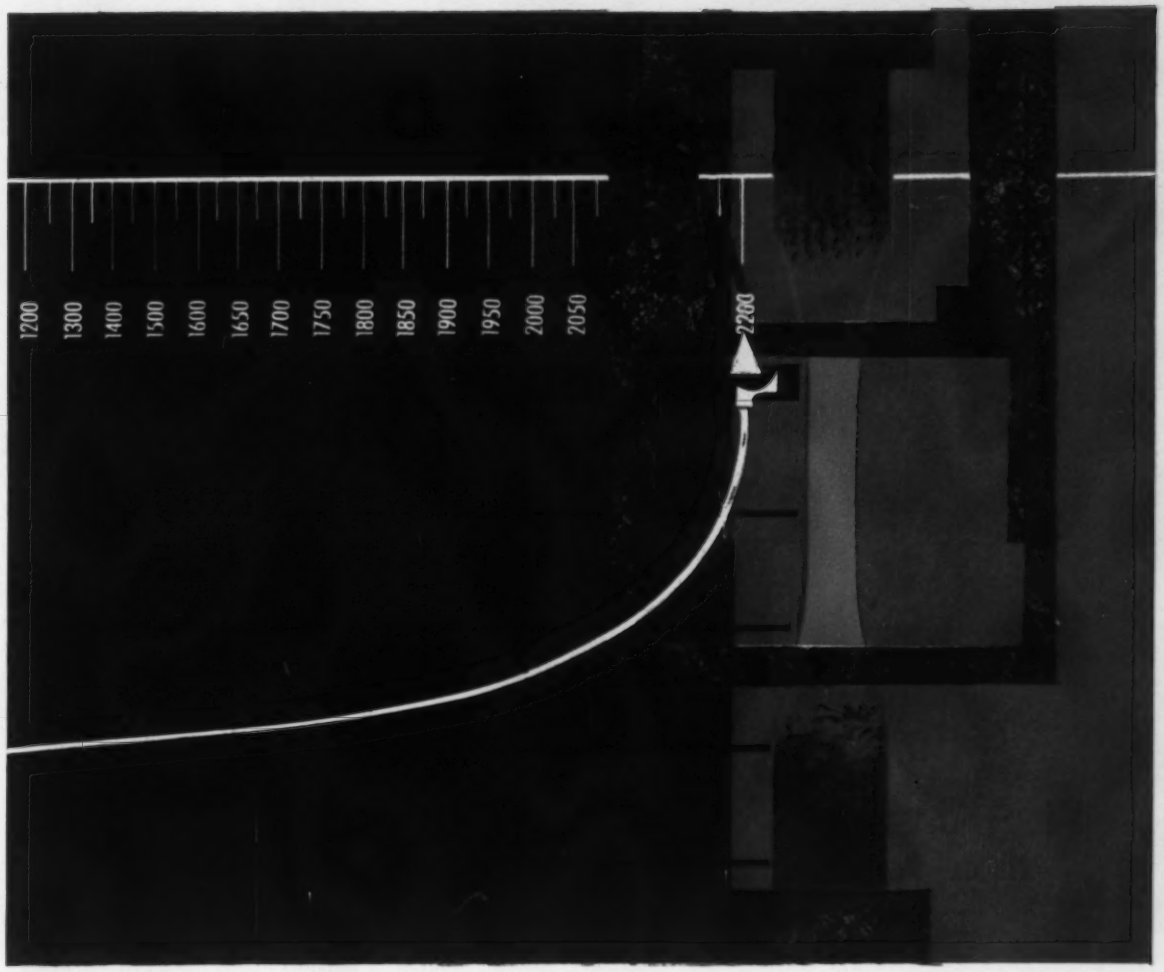
Transparent boat uses butyrate sheet 176

Flexible circuits use vinyl-copper sandwich 178



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Still other alloys in the family provide heat resistant castings with special resistance to scale . . . or thermal shock . . . thermal fatigue . . . stress-corrosion cracking . . . sigma phase embrittlement.

New booklet gives details

Our new booklet, "Heat and Corrosion-Resistant Castings, their Properties and Applications", has just come off the press. It contains a wealth of data. May we send you a copy?

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HH	13	26	HU	39	19
HI	16	28	HW	60	12
HK	20	26	HX	66	17

*Alloy Casting Institute

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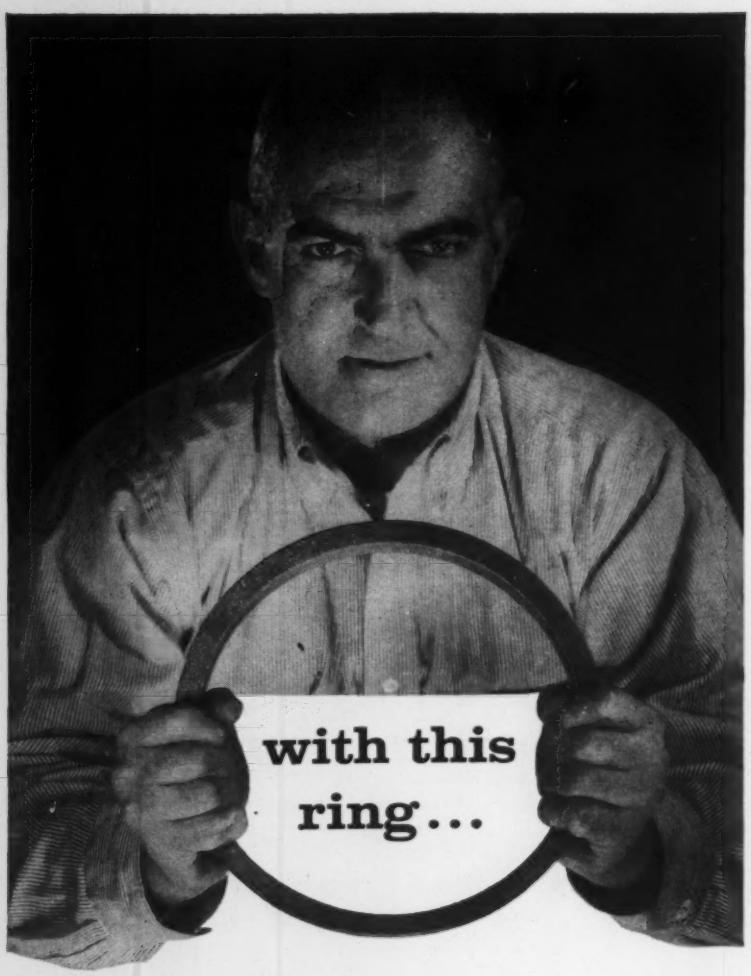

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Gold Coating Protects Rockets From Heat

Gold coatings are providing an effective solution to the heat problem posed by space age rockets.

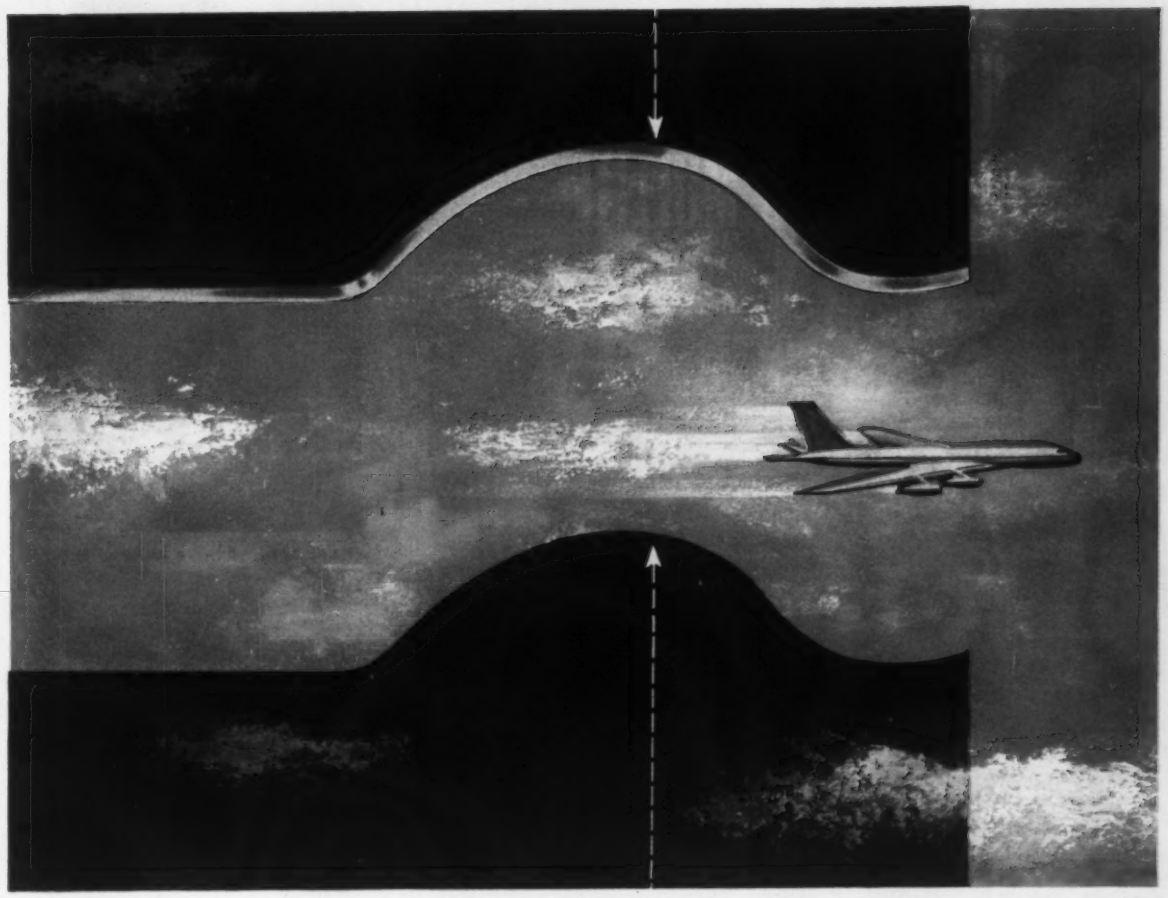
According to Chance Vought Aircraft, Inc., the precious metal is being specified for skins of aerospace vehicles because it provides high heat reflectivity, a relatively high melting point (almost 2000 F), low spectral emissivity and excellent corrosion resistance.

Protects nose cone

In one application, the nose cone of the Scout rocket, the entire inner skin is gold coated to protect scientific instruments from the extreme heat caused by atmospheric friction. The coating is only 0.00001 in. thick and only costs 60¢ a sq ft to apply. The outer skin is coated with a high-emissivity ceramic material that radiates friction heat back into the atmosphere.

Applying gold coatings is rela-

Formed vinyl props—The young lady shown above is not quite as strong as she looks. The fire hydrant and radiator she's carrying are actually stage props and weigh almost nothing. They were vacuum formed from sheets of rigid vinyl by the Plastics Dept. of CBS Television. According to B. F. Goodrich Co., vinyl sheet is ideal for this use because it is easily formed, lightweight, strong, tough, flame resistant, and easily cleaned with soap and water.



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High-temperature tooling: Metal-forming stretch dies that can operate at temperatures over 400° F.

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Long-lasting metal-forming tools: Castings made of formulated Epon resin, mounted in a crank press, showed no permanent deformation after 28,000 compression-shock cycles.

For tool and die applications, Epon resin formulations offer you the following important advantages:

Excellent tolerance control: Little machining and handwork are required to finish Epon resin tools because of the material's excellent dimensional stability and lack of shrinkage.

Outstanding strength: Jigs and fixtures with thin cross sections can be built from Epon resin-based formulations reinforced with glass cloth. The resulting laminate has high flexural strength and excellent dimensional stability.

Easy modification: Tools and fixtures made from Epon resins may be quickly and easily modified to incorporate design changes.

CONTACT YOUR TOOLING RESIN FORMULATOR

The combination of resin formulator's skill and application knowledge, backed by Shell Chemical's research and resin experience, has solved many important tooling problems for industry. For a list of experienced tooling resin formulators and additional technical information, write to:

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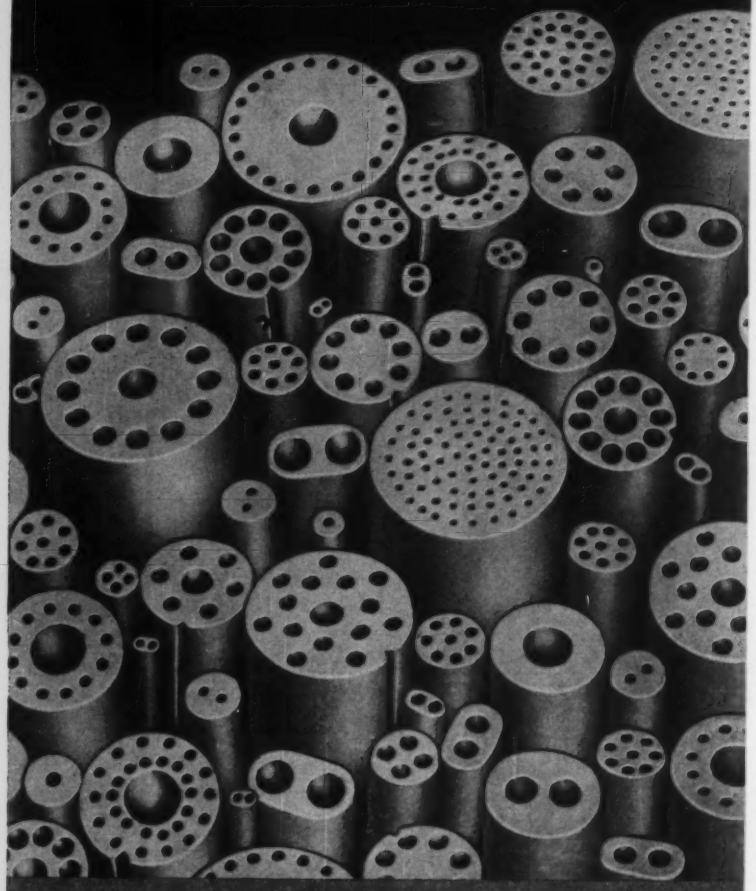

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***Inner skin of nose cone** is sprayed with gold coating.*

tively simple: electrolytic and vapor deposition methods are generally used. In the case of the Scout rocket, however, the parts are too large for either of these methods. The technique chosen is centuries old: a gold resinate soluble in pine oil is sprayed on the part which is then given a preliminary 15-min bake at 375 F. A second bake—time 1 hr at 700 F—turns the coating to pure gold.

Protects printed circuits

Another use of gold coatings in aircraft and missiles is on printed copper electrical circuits and contacts. A 0.000002-in. thick layer of gold, deposited by ionic decomposition, is used to extend storage life and to improve solderability by increasing copper's resistance to oxidation and tarnish.

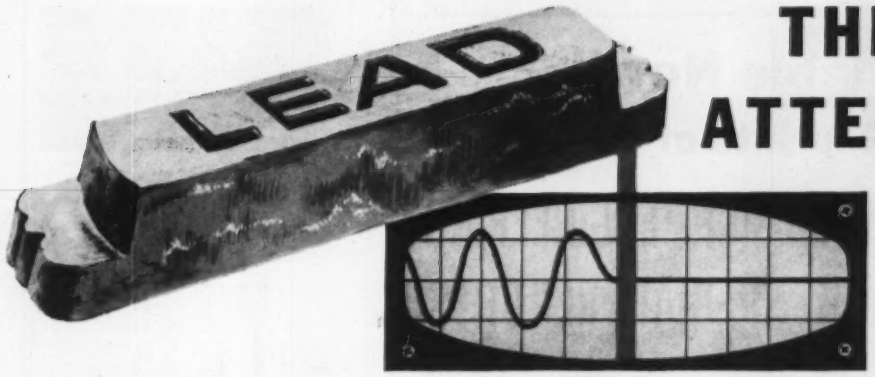
Aluminum Housing for Outdoor Switchgear

An aluminum housing is providing what is said to be the "first conclusive answer to the problem of corrosion in outdoor switchgear."

Called Aluma-Clad and developed by Allis-Chalmers Mfg. Co. in conjunction with Reynolds Metals Co., the new housing consists of interlocking extruded aluminum panels formed into walls, floor and roof which are fastened with aluminum bolts and neoprene gasketing.

In addition to corrosion resistance, and hence elimination of painting, the new housing offers three additional advantages:

1. Increased flow of air, resulting



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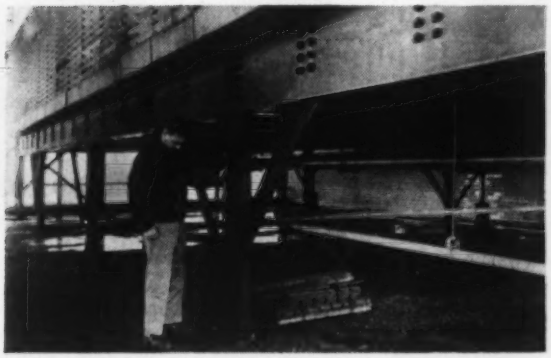
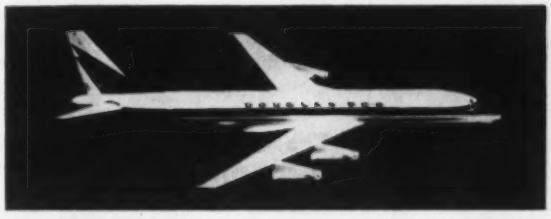
*Attenuation — Diminution of force, intensity, etc.

No other material equals LEAD'S combination of effective attenuation, low cost and compactness



IN DAMPING VIBRATION

Lead anti-vibration pads have proved an effective barrier to vibration created by railroad trains, printing presses, commerical laundry equipment and similar machinery. In the installation shown here, the roof-top cooling tower for an air conditioning system is mounted on lead pads which isolate the vibration from the building.

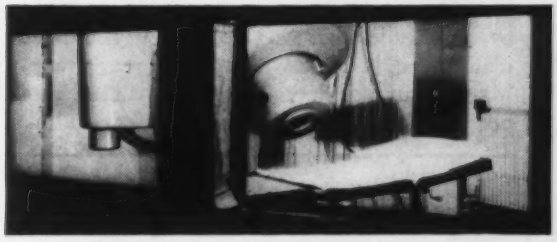


IN QUIETING NOISE

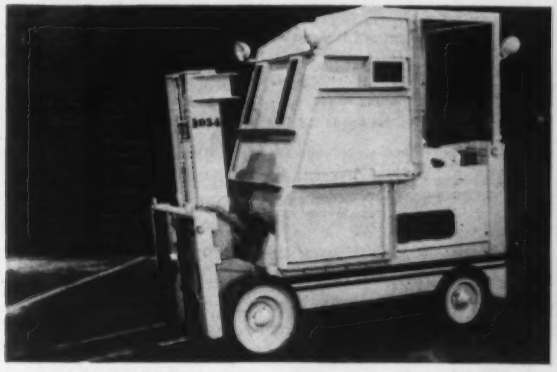
Because it is a dense, limp material, lead is an excellent sound attenuator and isolator. In powder form it is impregnated into the vinyl covering of a new acoustical fabric used to cut down engine roar in both conventional and jet airliners. This leaded fabric is also being used for sound attenuation in other applications such as electric typewriters.

IN RADIATION SHIELDING

X-RAY – Lead has long been the standard material for protection against harmful exposure to X-rays. It is used in the floors, walls, ceilings, doors and windows of X-ray rooms, in the protective clothing for technicians and in the beam-shaping apparatus of the machine itself.



GAMMA RAYS – Attenuation of gamma radiation is directly proportional to the density of the shield. Since lead is the densest of all commonly available materials, it gives the best protection per unit of thickness at lowest cost. It is widely used in nuclear reactors, radioactive waste containers and nuclear laboratories. Photo shows a lead-shielded fork lift truck with leaded glass viewing ports, used for transporting radioactive materials.



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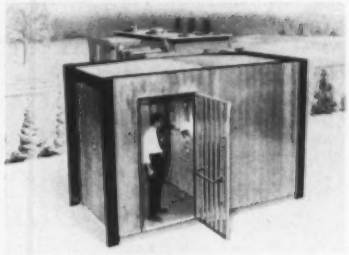
MATERIALS AT WORK



***Corrosion resistance** is major advantage of aluminum housing.*

***Extruded panels** snap together to form watertight joints.*

from the open-labyrinth cross section of the snapped-in-place extrusions (see accompanying photo), minimizes internal heat. Heating from external radiation is negligible due to the high reflectivity of the outside surfaces.

2. The interlocking floor sections are easily removed for inspection of the area beneath the switchgear.

3. Aluminum's light weight permits the use of concrete piers instead of slabs, and eliminates the need for cranes during installation.

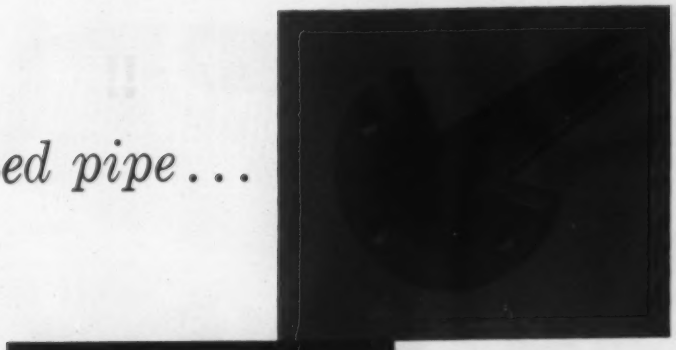
Transparent Boat Uses Butyrate Sheet

The latest thing in small, lightweight plastics boats is the transparent unit shown in the accompanying photo.

The boat, vacuum formed from tough cellulose acetate butyrate sheet, weighs only 44 lb, yet carries up to 600 lb afloat. Its primary advantages, in addition to light weight, are elimination of maintenance (it won't corrode and requires no finish), transparency and high impact strength.

The boat, manufactured by Sudbury Laboratory, Sudbury, Mass.,

In lined pipe...



hose...

seals...

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The result of designing with TEFLON is longer service life, reduced replacement costs, reduced maintenance costs and far greater reliability. TEFLON fluorocarbon resins are available in easily machined standard shapes. Flanged pipes and fittings lined with TEFLON TFE resins are available in a complete assortment of standard sizes. In flexible hose, new constructions include fiber reinforcements, elastomeric coverings and a variety of industrial couplings.

The next time you have a difficult fluid-handling problem, consult your supplier about the advantages of TEFLON resins in pipe, flexible hose or sealing applications. For detailed information about the properties and characteristics of TEFLON resins, send for the booklet "Designing with TEFLON", write to: E. I. du Pont de Nemours & Co. (Inc.), Polychemicals Dept. T-26-6, Room 2526, Nemours Bldg., Wilmington 98, Delaware. **In Canada:** Du Pont of Canada Limited, P.O. Box 660, Montreal, Quebec.

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SAFETY PILOT

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When Janitrol designed the new J-LINE gas-fired counter-flow furnaces for basementless homes, they aimed at producing equipment to meet the highest contemporary standards for performance, economy and dependability. Precision-built throughout, the J-LINE models feature slim-trim styling, compactness, factory fire-testing, "deep well reservoir" pre-lubricated sintered bronze bearings for blowers, safe, sure, positive controls, acoustical insulation and, of course, a new safety pilot incorporating Chace Thermostatic Bimetal. The action of this sensitive bimetal element prevents the flow of gas to the pilot and the main burners should the pilot light be extinguished.

Here again is an example of precision control making an appliance so thoroughly safe that it is installed without hesitation by hundreds of thousands of contractors and home owners, usually close to the center of the living area itself. Janitrol buyers know that gas is the cleanest and *safest* of fuels because of Janitrol's specialized skill and experience in building home comfort equipment to highest quality standards for over half a century. Chace, too, has concentrated for over a third of a century on the development and manufacture of one outstanding product, precision thermostatic bimetal for thousands of applications — temperature control and indication and equipment protection. That's why Chace customers *know* their names are safe on the "outside" with Chace bimetal "inside."

If your new product is approaching the design stage, send for "Successful Applications of Chace Thermostatic Bimetal." It contains illustrations and design data on more than 30 types. Remember, too, Chace bimetal is available in strips, coils and in completely fabricated elements of your design.

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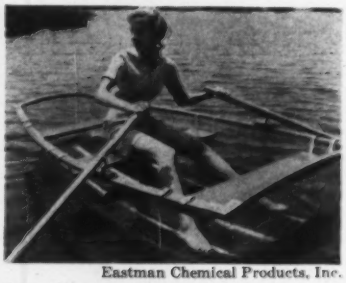


Eastman Chemical Products, Inc.

***See-through floor** adds to fun.*

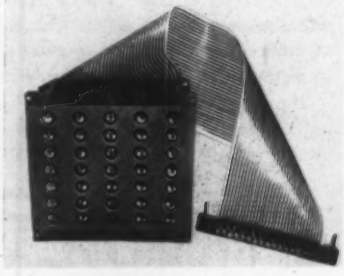
is described as an 8-ft pram that can be powered either by oars or by a 3-hp motor. The clear hull, fitted with mahogany seats and gunwhale, is ideal for quick selection of the best spots for fishing, skin diving or study of fish and marine life.

Flexible Circuits Use Vinyl-Copper Sandwich

Flexible printed circuits, consisting of thin copper conductors sandwiched between layers of flexible vinyl sheeting, are simplifying the design of electronic and electrical systems.

According to Sanders Asso., Inc., the circuits are easily routed through crowded layouts and are therefore ideal for use in computers, telephone and telegraph switchgear, relays, and industrial controls.

According to Union Carbide Plastics Co., vinyl was selected because it provides flexibility and good insulating properties at low cost. In addition, its excellent resistance to corrosive chemicals permits its use in aircraft and missiles.



***Flexible printed circuit** is expected to be used in computers, industrial controls and missiles.*

Constant opening and closing of refrigerator-freezer door simulates a portion of cabinet's expected life.

PERFORMANCE TESTS FOR NEW APPLIANCES

Admiral's 1960 thin wall refrigerator-freezer pre-proved in use at Owens-Corning Fiberglas new Testing Laboratory

Thermal insulation efficiency... over-all equipment reliability.

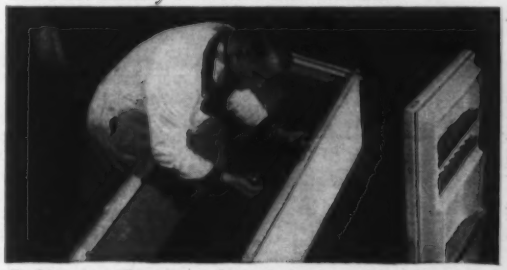
These were the subjects of an intensive 10-week appliance "*Life Test*" on the 1960 Admiral thin-wall refrigerator-freezer. Owens-Corning Fiberglas engineers subjected the refrigerator-freezer and its insulation to extreme conditions of temperature, humidity and usage. The results confirm design reliability. This cabinet exemplifies the trend to thinner walls which benefits consumers by increasing storage capacity without decreasing kitchen work space. Admiral is one of the leading manufacturers who are using new pink Fiberglas* AF Refrigerator Insulation to achieve thinner walls.

This Owens-Corning testing program, one of many services available to the appliance industry, is proof-in-use of a highly efficient refrigerator . . . with the leading thermal insulation in the industry.

* * *

Interested manufacturers may contact Owens-Corning Fiberglas Corporation, Dept. 231-F, Toledo 1, Ohio, for additional information on the availability and scheduling of the newly enlarged Owens-Corning Fiberglas Testing Facilities.

Humidity and temperature test conditions are precisely and automatically controlled and recorded.



Refrigerator-freezer and insulation are carefully examined for conformance with rigid test performance standards.

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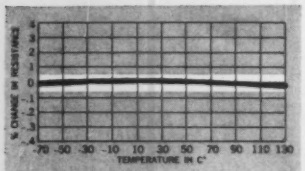

Percent change in resistance of an ideal sample of Evanohm. Normal production material (.002" and finer) is supplied within the range ±10 ppm (–65° to 25°C. and 25° to 125°C. referred to 25°C.)

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TECHNICAL LITERATURE

(cont'd from p 47)

Books

Three Basic Books on Metals.

Tin and Its Alloys. *Edited by E. S. Hedges. St. Martins Press, Inc., New York. 1960. Cloth, 7½ by 10 in., 432 pp. Price $27.50*

The various chapters in this book discuss tin in wrought and cast form, physical metallurgy of tin and tin alloys, chemical behavior of tin, electrodeposition of tin and its alloys, hot tinning, tinplate, tin in bearing alloys, die casting and other tin alloys, solders, and bronzes.

Malleable Iron Castings. *Malleable Founders Society, Cleveland. 1960. Cloth, 6 by 9 in., 530 pp. Price $10*

The content of this up-to-date handbook has been expanded by more than 40% over the previous edition, published in 1944. In the present volume new emphasis has been given to pearlitic malleable iron.

Other chapters discuss uses of malleable iron castings, physical properties of standard malleable iron, alloyed malleable irons, design and manufacture of malleable iron castings, and machining and metallurgy of malleable iron.

The book is well illustrated with tables and photographs, and contains an index, glossary and bibliography.

Magnesium and Its Alloys. *C. S. Roberts. John Wiley & Sons, Inc., New York. 1960. Cloth, 6 by 9 in., 240 pp. Price $9*

This book gives a balanced picture of the scientific principles and technological know-how involved in the fabrication and use of magnesium. The extraction, refining and casting of the metal, as well as its chemical and physical properties are covered in detail.

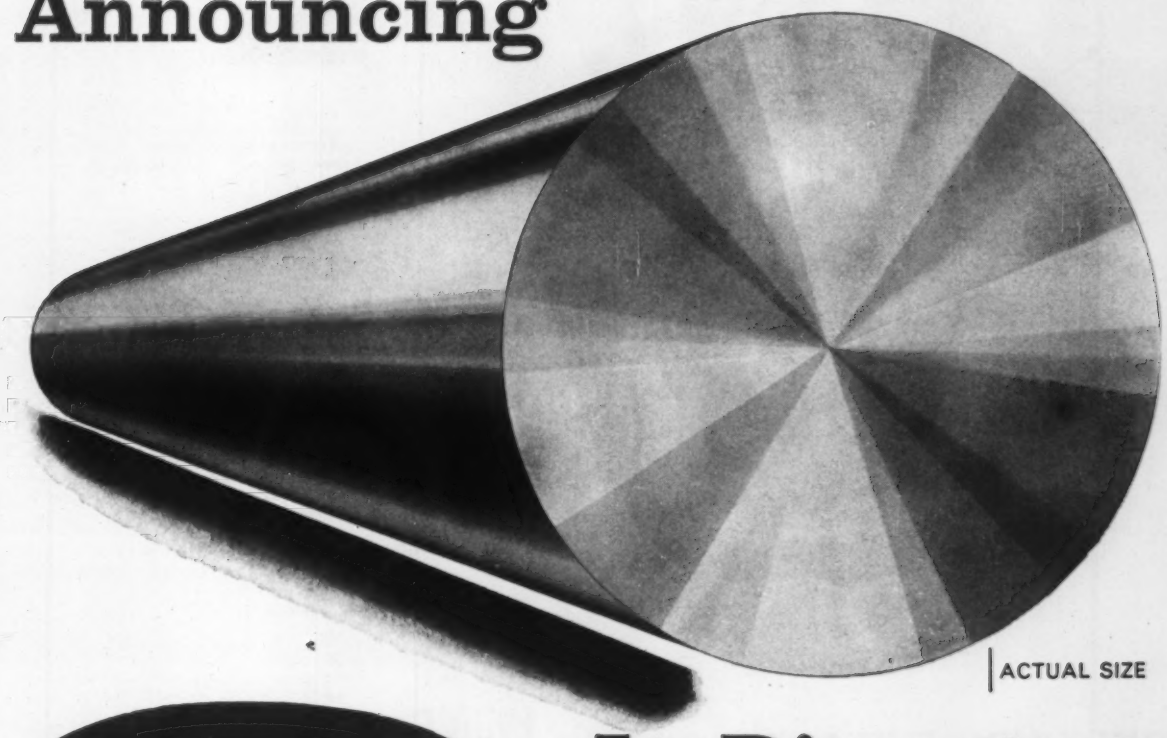
Plastics Testing and Standardization. *American Society for Testing Materials, Philadelphia. 1959. Cloth, 6 by 9 in., 276 pp. Price $6*

Tells how plastics standards are achieved in various countries. Also gives mechanical and thermal properties of plastics, and discusses molecular characterization of polymers.

Mechanical Properties of Intermetallic Compounds. *Edited by J. H. Westbrook. John Wiley & Sons, Inc., New York. 1960. Cloth, 6 by 9 in., 445 pp. Price $9.50*

Subject matter of this book may be divided into five categories: 1) a review of the literature on the properties of intermetallic compounds, 2) effects of crystal structure and temperature on properties, 3) experimental techniques for studying the mechanical behavior of these materials, 4) effects

Announcing



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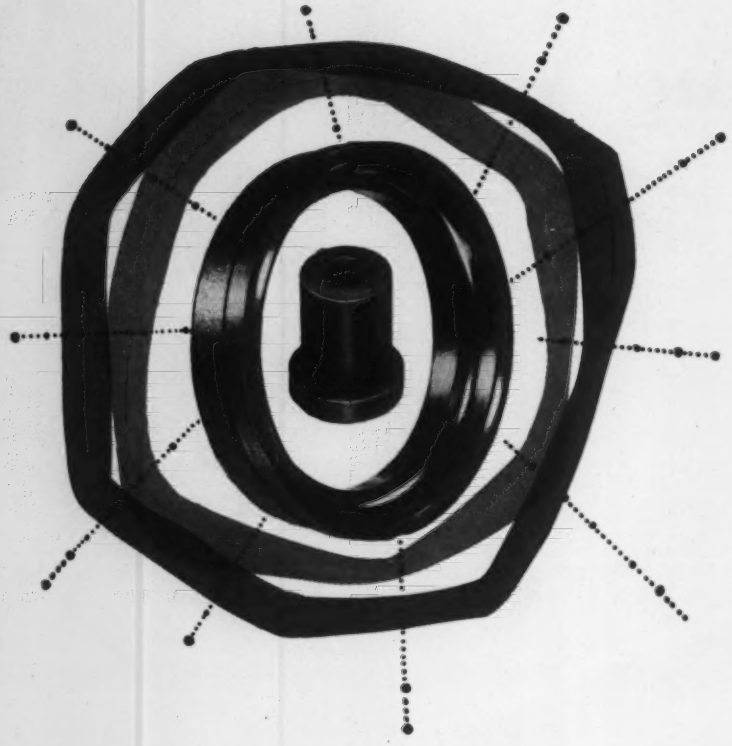

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TECHNICAL LITERATURE

ot dislocations and point defects on the properties of these materials, and 5) mechanical phenomenology of specific intermetallic compounds.

Amino Resins. *J. F. Blais. Reinhold Publishing Corp., New York. 1959. Cloth, 5 by 7½ in., 230 pp. Price $4.95*

Covers chemistry, manufacture and major applications of urea and melamine resins, and the newer ethylene urea and benzoguanamine. The book describes in detail amino resin applications in adhesives, textiles, paper, and surface coatings.

1958 References on Fatigue. *American Society for Testing Materials, Philadelphia. 1959. ASTM Special Technical Publication No. 9-J. Cloth, 8½ by 11 in., 76 pp. Price $3.50*

References to articles published in 1958 dealing with fatigue of materials and structures.

Reports

Selenium, tellurium SELENIUM AND TELLURIUM ABSTRACTS: VOLUME 1, NO. 6. *28 pp. 1960. Selenium and Tellurium Development Committee, Battelle Memorial Inst., 505 King Ave., Columbus 1, Ohio.*

Abstracts of articles dealing with properties and uses of selenium and tellurium.

Tapes, adhesives MANUAL OF PRESSURE SENSITIVE PRODUCTS. *1960. Mystik Adhesive Products, Inc., 2635 N. Kildare Ave., Chicago 39. Price $2*

Physical characteristics and uses of industrial tapes, bulk adhesives, coatings and other pressure sensitive products.

High temperature lubricants DEVELOPMENT OF OSCILLATORY PLAIN BEARINGS AND LUBRICANTS FOR AIRFRAME APPLICATIONS IN THE TEMPERATURE RANGE -90 TO 1500 F. *W. A. Glaeser, C. M. Allen, W. J. Zielenbach and W. H. Goldthwaite, Battelle Memorial Inst. Apr '59. 62 pp. Available from Office of Technical Services, Dept. of Commerce, Washington 25, D. C. Price $1.75 (PB 161051)*

Discusses materials for use as high temperature airframe bearings and lubricants. The report concludes that although bearing and shaft materials apparently can be developed for use at temperatures from -90 to 1500 F, there is no lubricant that will cover the entire range.

Metal transmission fluids RESEARCH ON LIQUID METALS AS POWER TRANSMISSION FLUIDS: PART 2. *R. C. Kumpitsch, General Electric Co. May '59. 196 pp. Available from Office of Technical Services, Dept. of Commerce, Washington 25, D. C. Price $3 (PB 151876)*

Discusses a liquid metal alloy of sodium and potassium used as a hydraulic fluid over the temperature range 80 to 1000 F at cyclic pressures of 15 to 3000 psi.

Uranium alloys SELECTED DATA ON URANIUM ALLOYS. *H. C. Friedemann and H. H. Hausner. Sylvania-Corning Nuclear Corp., Bayside, N. Y. 76 pp. Price $1*

Bibliography of 470 references on uranium alloys arranged by authors' names. Tables and graphs show behavior of some uranium alloys under conditions of corrosion and irradiation.

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Ceramics—cont'd from p 23

limit of what can be done with metals and must turn to ceramics . . . We are running out of materials that can withstand extremely high temperatures and also possess sufficient ductility to meet construction requirements. We know that we can make more ductile ceramics and we know that we can create new design concepts that will permit us to use brittle materials."

Intensified research needed

Speaking at the recent 62nd annual meeting of the American Ceramic Society, Dr. Townsend also pointed out that intensified research and easier availability of information is needed ". . . if we are to have the kinds of materials we need, when we need them." One attempt along these lines is the ceramic information center now being considered by the Dept. of Defense.

Some of the areas of ceramic research that are particularly vital are: 1) Use of rare earth oxides as high temperature refractory materials; 2) simplified procedures for producing radomes, nose cones, insulation, coatings, adhesives and rocket nozzles; 3) studies of the effect of radiation on ceramics; 4) use of ceramics for structural and semi-structural components at temperatures up to 3500 F; and 5) bonding of ceramics to metals as coatings to withstand high temperatures, radiation erosion and corrosion.

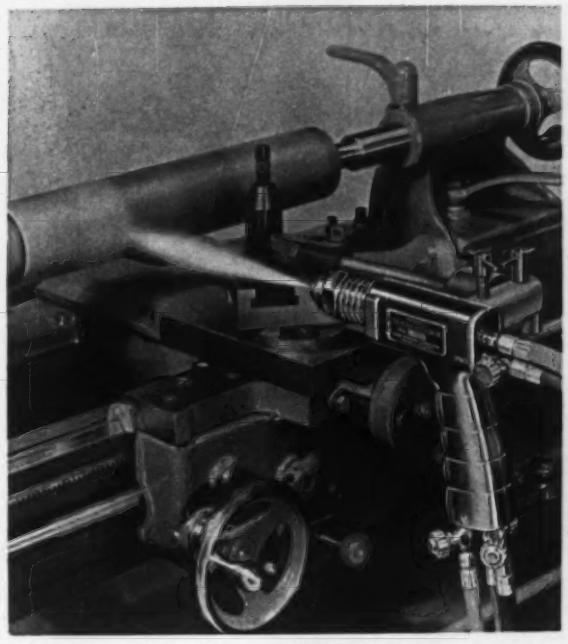
Shortage of ceramic engineers

Another problem, perhaps as important as the problems of research and dissemination of information, is the shortage of ceramic engineers.

According to Dr. John R. Koenig, Head of the Dept. of Ceramics, Rutgers University, "Twice as many ceramic engineers, ceramic technologists and glass technologists are needed to carry out and develop programs vital to our missile and space program."

Lead-Zinc Research Discussed at Meeting

Extensive use of galvanized steel in automobiles is one aim of the research efforts of the combined Lead



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Industries Assn. — American Zinc Inst. Expanded Research Program.

A progress report on this and other current research was one of the highlights of the LIA-AZI annual meeting recently held in St. Louis. The meeting had the highest attendance ever recorded.

Research program

The cooperative research program is aimed at: 1) developing new uses for lead and zinc; 2) improving present uses; and 3) developing new lead and zinc-base alloys.

One of the more interesting programs reported on was the use of galvanized steel in automobiles. The purpose is to reduce corrosion in remote areas that cannot be reached. The principal problem to be solved is the development of a high speed, production-line welding process (galvanized steel can be welded but not efficiently). A vigorous research program will be initiated.

Use of lead to increase

Several papers presented by the Lead Industries Assn., especially those on storage batteries, automobile power plants, building construction and acoustics, were frankly optimistic about the future need and expanded use of lead. Only one paper, dealing with lead in the cable industry, cited a downward trend.

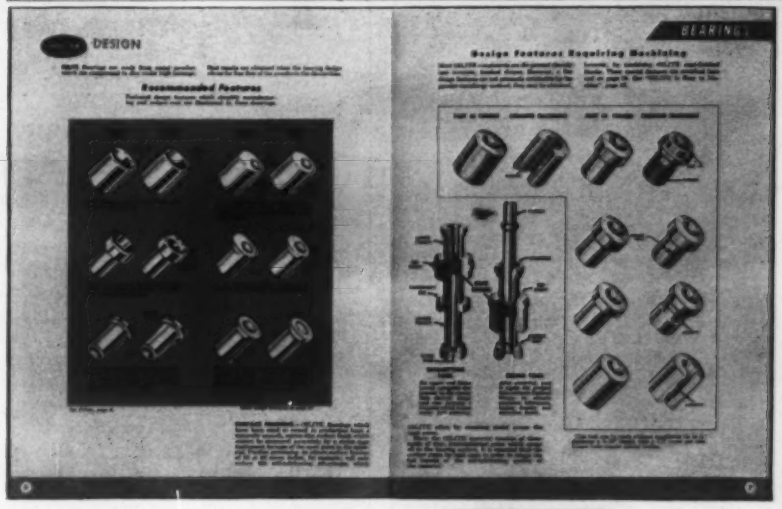
The annual report described several approaches to the problem of "health and lead." More research programs will be initiated to determine the effects of lead (in all its forms and compounds) on health of users. The program will be aimed at determining the levels above which absorption of lead is harmful.

Zinc use near record

The international picture in lead and zinc production and use was covered in detail. According to Mr. R. Hendricks, Consolidated Mining & Smelting Co. of Canada, world use of zinc in 1959 almost reached the peak level of 1955. Others pointed out that though use of zinc is increasing generally, zinc oxide and zinc-containing brasses are either holding their own or decreasing.

On the other hand, although rolled zinc products have shown a decline in the last 15 years due to competition from aluminum, galvanized iron, plastics, etc., this trend is expected to reverse.

POWDER METALLURGY ENGINEERING MANUAL



HOW TO determine the correct applications for self-lubricating bearings and powder metal parts. **Bearing** section includes: design features, computation of loads and speeds, calculating nominal dimensions, examples of designing for both new and existing applications —plus stock list of 1050 standard Oilite bearings. **Powder metal parts** section includes: typical properties, materials selection guide, design features, magnetic properties, information request form.

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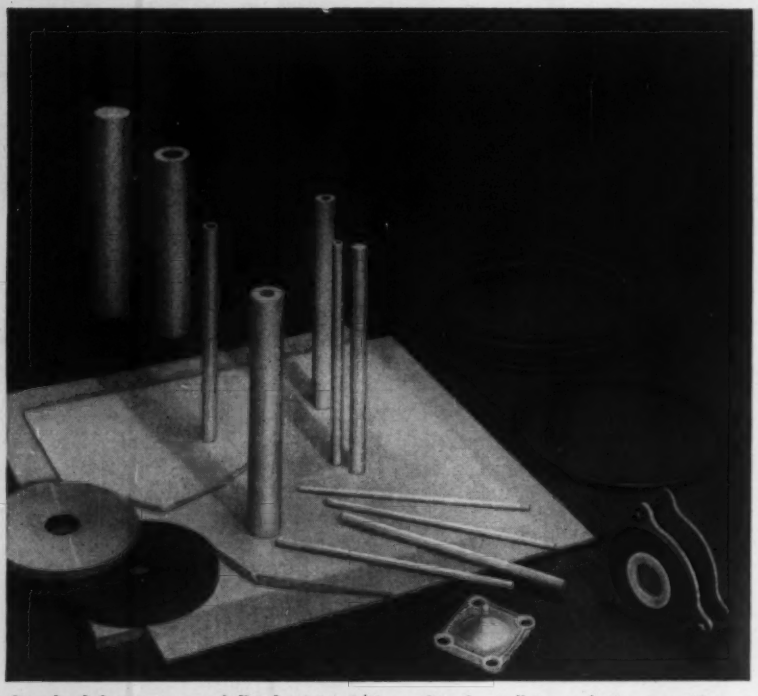

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SPECIALISTS IN ASBESTOS, RUBBER, ENGINEERED PLASTICS, SINTERED METAL

For more information, turn to Reader Service card, circle No. 342

What's new IN MATERIALS

(cont'd from p 12)

Chromizing Technique Is Efficient, Economical

A chromium diffusion method similar in many respects to conventional chromizing, gas nitriding and carburizing has been announced by Alloy Surfaces Co., Inc., 100 S. Justison St., Wilmington, Del. Advantages claimed for the process, called Alphatizing, include: 1. More parts can be processed in one operation because no inert materials, such as kaolin or alumina, are required in the treating vessel; 2. In general, conventional heat treating furnaces and accessories can be used.

A big use for the process is currently in chromizing mufflers. Other potential applications include fasteners, heaters, ovens, jet engines, turbine blades and vanes, rolls, wire screen, casings and heat exchangers.

How the process works

The developer says the complex chemistry of chromium diffusion has been simplified and controlled in the Alphatizing process by using a granular compound called Alphalloy (composition not revealed).

The material is said to offer many practical advantages over fine powders. It does not contaminate work areas with dust, and it does not sinter appreciably to itself or to the work-pieces. Another advantage: the granular compound and the work-pieces need not be in physical contact to effect chromizing.

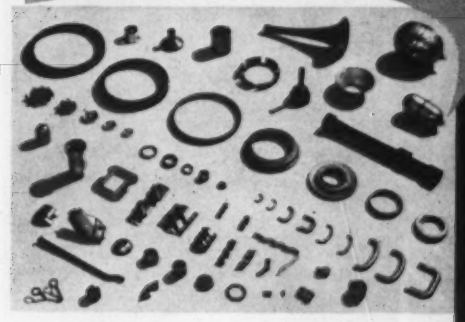
The Alphalloy is placed in a treating vessel along with the metal parts to be chromized. The action of heat on the material automatically produces the proper chromizing atmosphere. Purging of the sealed vessel is also automatically accomplished.

The chromized parts need only a water rinse. The Alphalloy compound can be stored for re-use in the next heat. **KEY NO. 606**

Polyethylene Resins for Molding, Coating

Five new polyethylene resins have been introduced recently. Two are molding compounds, one is a film-grade resin, and two are for coating

To Be Sure of Quality Controlled
DEEP DRAWN, LIGHT AND MEDIUM
METAL STAMPINGS
of exacting tolerances



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and
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HELP KEEP ICE CREAM COLD

It's cold inside Universal Cabinet's Model GT-23, which keeps ice cream and other frozen products at a constant degree of coldness. Separating this frigid atmosphere from the warm temperatures outside is a fog-free glass . . . framed in anodized aluminum extrusions by G.E.I. The G.E.I. sections perfectly fit both the glass and the cabinet to keep cold air in and warm air out. They slide freely and add beauty to the overall handsomeness of the cabinet.

This is another example of a leading manufacturer solving his requirements for durability, beauty and economy with G.E.I.'s uniform quality and unfailing delivery. Discuss your extruded aluminum needs—one part or a million—with G.E.I.

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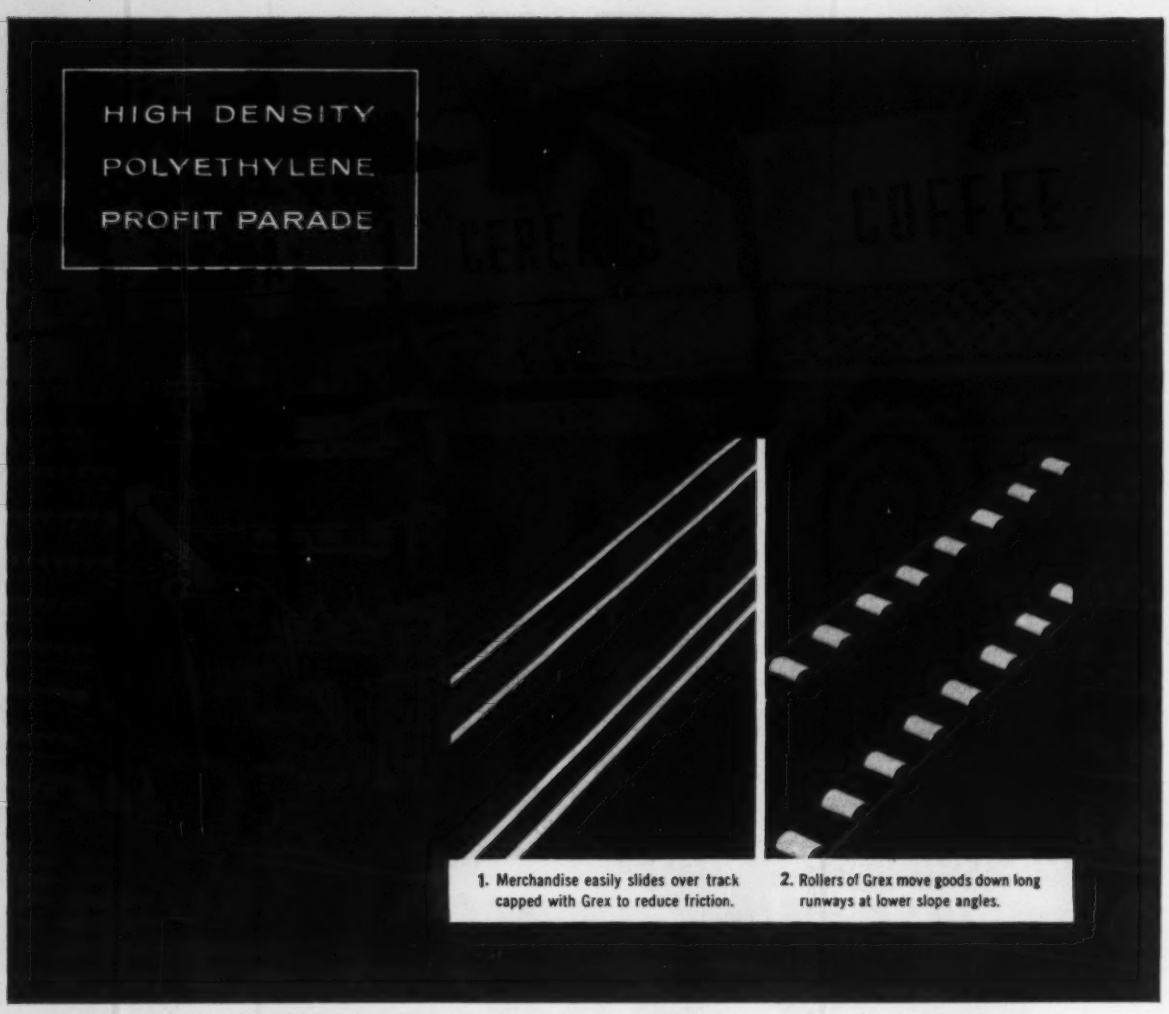
Each month Spincraft sends its "Notes for An Engineer's File" to qualified personnel in industry. Write us if you would like to receive these valuable reports.


HIGH DENSITY
POLYETHYLENE
PROFIT PARADE
1. Merchandise easily slides over track capped with Grex to reduce friction.
2. Rollers of Grex move goods down long runways at lower slope angles.

Grace Plastic Solves Friction Problem 2 Ways

North American Equipment Company finds that Grex high density polyethylene is the most practical material available for reducing friction in two types of gravity storage installations. These are utilized in both "Food-O-Mat" for supermarket merchandising and "Quik-Pik" for industrial order picking.

"Quik-Pik" units hold stock which automatically slides down a runway as items are picked from the front. The problem is friction. This friction is overcome in one type of installation by using runways capped with an extruded Grex tubing made by Action Plastics, Inc. Stock slides smoothly over Grex at a slope angle of 12°-14°. The other type of installation moves merchandise at an even lower angle (4°-6°) by utilizing tracks with Grex rollers that never require lubrication and never freeze up. Rollers are made by Gar-Mold, Sefton Div. of Container Corp. of America.

The manufacturer of "Quik-Pik" and "Food-O-Mat" is building a profitable business with superior products that exploit the remarkable properties of Grex. Perhaps you can do the same.

The best way to find out is by calling in the high density polyethylene experts. Grace has the production facilities, technical service and experience to help put your product in the Grex profit parade. Everyone says we're easy to do business with.

Grex is the trademark for W. R. Grace & Co.'s Polyolefins.

W.R. GRACE & CO.
POLYMER CHEMICALS DIVISION CLIFTON, NEW JERSEY

For more information, turn to Reader Service card, circle No. 483

How to find out for certain if Grex is suitable for your product.

The rather odd-looking device shown here is a "sliding" machine, invented in the Grace Physical Testing Laboratory. Its purpose was to test the performance of Grex capping for use on metal tracks in "Quik-Pik" installations. Since the tests were highly successful (the manufacturer uses Grex capping at the rate of 2,000,000 feet per year) the machine itself now serves only one function. It testifies that you can expect the same individual help in determining how Grex will work for your product.

Simulates use conditions. Although the Grace laboratories are equipped with every standard physical testing device, it is often difficult to simulate conditions of product usage without devising special equipment. The "sliding" machine is one example of such a device. It was developed to measure abrasion resistance of Grex capping under simulated use conditions. A container is placed at the top of the machine, slides through two tracks and is automatically lifted to the top again for a new cycle. In this way it was possible to simulate two years of usage within a short period of time and determine that the capping would provide satisfactory performance.

Other examples. Ingenious is the word to describe other devices specially built to test performance of Grex applications. A mechanical foot was invented to simulate the operation of a step-on garbage can. By running the can through some five thousand cycles, weaknesses were spotted and corrected to make a satisfactory product. Similarly, a method was devised for testing a series of pulleys under identical conditions to determine the most suitable design and resin grade.

Do you want help? Physical testing is only one of several facets of Grace technical service at your command. If you have an application for high density polyethylene—or think you have—now's the time to contact:

Technical Service Department
W. R. Grace & Co., Clifton, N. J.

paper and other materials.

1. Molding resins

▸ Dow Chemical Co., Midland, Mich. has introduced a bacteria-fighting polyethylene molding compound called Surfaseptic. Dow research men say the compound is especially effective as an active killer of the disease producing staphylococcus organisms.

The new compound, available in granular and pellet form, is expected to find use in such things as toys, waste baskets, door knobs, telephone head sets and arm rests.

Dow says it expects Surfaseptic polyethylene will carry little or no price premium. **KEY NO. 643**

▸ Another polyethylene molding resin, called Petrothene 101 and developed by U. S. Industrial Chemicals Co., Div. of National Distillers and Chemical Corp., 99 Park Ave., New York 16, is specifically designed for blow and injection molding. The resin, with a density of 0.924 gm per cu cm and a melt index of 2.0 gm per 10 min, is characterized by

Laminated butyrate sheet—The sign shown here was produced from a new laminated butyrate sheet in two quick operations. First, a black and white laminated sheet was vacuum formed. Then, decorating was done by sanding off the white layer to let the black show through on the surfaces of the raised letters and arrow.

The laminated sheet is available from Rowland Products, Inc., Kensington, Conn. It is supplied in various color combinations in 24-in. widths, and in lengths up to 54 in. **KEY NO. 605**

FIREBIRD PRODUCTS
for
PLASMA SPRAYING

New and exciting applications for NORTON FIREBIRD PRODUCTS are now possible. Commercial plasma spray equipment has extended the range of materials which can be utilized, so that now you can take advantage of the unusual and valuable properties of Borides, Carbides, and Nitrides in addition to Oxides as coatings.

These materials are now available from NORTON COMPANY in powder form, sized specifically for the various types of commercial spray equipment used today.

Investigate the possibilities of utilizing these high melting point products: their resistance to high temperature abrasion, erosion and corrosion and their electrical conductivity . . . both as coatings and shapes fabricated by Plasma Spraying.

Write NORTON COMPANY, Electro-Chemical Division. 345 New Bond Street, Worcester 6, Massachusetts.

Send for Bulletin,
"Norton Materials for Plasma Spray Coatings."

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GIFTS OF THE FIREBIRD: compounds of silicon zirconium • boron • aluminum • magnesium titanium • chromium • including many borides carbides • nitrides • oxides

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Making better products...
to make your products better

For more information, circle No. 410

No. 14 of a series

Eastman 910 Adhesive solves another production bottleneck

Hilliard Corporation, of Elmira, N. Y., manufacturers replaceable oil-filter elements for military and industrial use.

The element consists of a perforated metal tube surrounded by a pleated paper cylinder. The paper cylinder is held tightly against the tube with snug-fitting paper retaining bands.

Vital to proper filter operation, the bands are formed by wrapping a strip of wax-impregnated paper around a mandrel, then overlapping the dewaxed ends and bonding them together with a drop of Eastman 910 Adhesive.

Use of this fast-setting adhesive reduces the time for this operation by 50% compared with a hot iron heat-sealing method employed formerly.

Eastman 910 Adhesive is making possible faster, more economical assembly-line operations and new design approaches for many products. It is ideal where extreme speed of setting is important, or where design requirements involve joining small surfaces, complex mechanical fasteners or heat-sensitive elements.

Eastman 910 Adhesive is used as it comes. No mixing, no heating. Simply spread the adhesive into a thin film between two surfaces. Light manual pressure triggers setting. With most materials, strong bonds are made within minutes.

What production or design problem can this unique adhesive solve for you?

For a trial quantity (1/3-oz.) send five dollars to Armstrong Cork Co., Industrial Adhesives Div., 9106 Dunbar Street, Lancaster, Pa., or to Eastman Chemical Products, Inc., Chemicals Div., Dept. E-6, Kingsport, Tenn. (Not for drug use)
See Sweet's 1960 Prod. Des. File, 7/E

For more information, circle No. 427

What's new IN MATERIALS

high stiffness, good stress crack resistance, excellent appearance and easy processability.

The stress crack resistance of Petrothene 101 was tested using an accelerated shelf-life test for detergent bottles. The resin was extruded into thin wall tubes which were then filled with a commercial detergent and sealed at both ends. None of the containers showed any sign of failure after four months' exposure at a temperature of 120 F.

The resin is expected to be used for detergent bottles and rigid containers. **KEY NO. 644**

2. Film-grade resin

▸ U. S. Industrial Chemicals (address above) has also introduced a film grade polyethylene resin called Petrothene 112. Film made from the resin is said to have exceptional toughness combined with high clarity and high gloss. The resin can be processed by the blown, flat or cast film-making procedures.

Petrothene 112 polyethylene is available in an unmodified form and also in medium and high slip formulations. **KEY NO. 645**

3. Coating resins

▸ A polyethylene coating resin called Petrothene 205-15 is another new product of U. S. Industrial Chemicals Co. The resin, which has a density of 0.924 gm per cu cm and a melt index of 3.0 gm per 10 min, is said to adhere well to a variety of materials. It is also said to provide 100% greaseproofness at a lower coating weight than other resins of similar melt index and density.

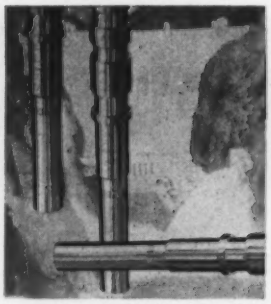
The flow characteristics of the new resin are well suited for high speed extrusion coatings. Coatings as thin as 0.5 mil can be applied easily, according to the producer.

KEY NO. 646

▸ Union Carbide Plastics Co., Div. of Union Carbide Corp., 420 Lexington Ave., New York 17 is marketing a new high density polyethylene coating compound called DGDD-

INDEX TO M/DE

A detailed subject index to Volumes 51 and 52 (i.e., January through December, 1960) of Materials in Design Engineering will be made available at the end of the year.



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call WESTERN UNION operator 25

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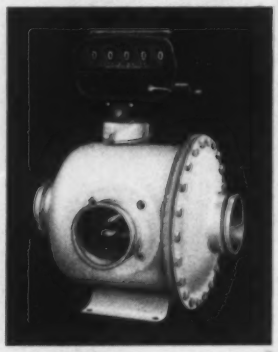
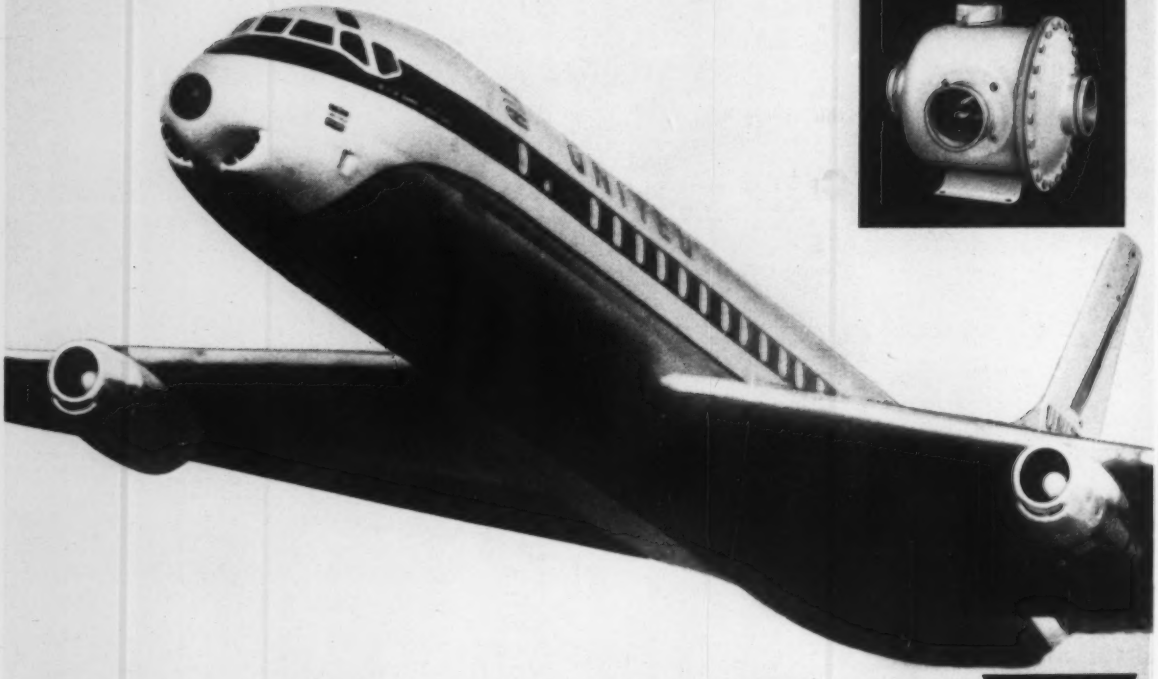
Big jet aircraft make money only when they are in the air. Every minute they are earthbound is costly. You just can't take chances on failure of aircraft engines from fuel contamination, or on failure of refueling equipment. That's why those parts of Brodie BiRotor refueling meters and control valves that come in contact with the fuel are chemically plated with KANIGEN nickel alloy.

Brodie BiRotor meters have been used for controlling aircraft refueling for many years, and their internal parts have been KANIGEN-coated ever since this highly accurate method of plating difficult or complicated surfaces was perfected.

Do you have a corrosion or contamination problem? Is it a small part like the Brodie meter housing? Or is it a surface as large as the inside of a 20,000 gallon tank car? Whatever it is, there's a way to solve your problems with KANIGEN chemical nickel plating. Write or phone the nearest General American office.

It pays to plan with General American.





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Chicago 3, Illinois
Offices in principal cities

KANIGEN GENERAL AMERICAN

For more information, turn to Reader Service card, circle No. 419

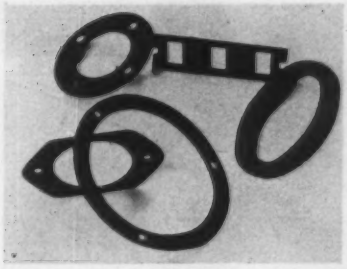
7401. The material can be extruded onto paper in coating weights as low as 6 lb per ream. Formerly, 20 lb per ream was the lowest practical coating weight possible with high density polyethylene. KEY NO. 647

Rubber Gasket Material Seals Corrosive Gases

American Felt Co., 2 Glenville Rd., Glenville, Conn. has introduced an improved fiber-reinforced nitrile rubber (NBR) gasket material for sealing corrosive gases and liquids under high and low temperature conditions.

The material, called Vistex III, is said to have good compression recovery, good flexibility, and good resistance to acids, alkalis, and aliphatic and aromatic solvents. A 1/16-in. thick specimen of the material has a tensile strength of 4000 psi.

The material is supplied as sheets measuring 30 by 60 in., in thicknesses from 1/64 to 1/8 in. The sheet can be precision cut into gaskets, strips and washers. KEY NO. 648



***Gasket material** can be cut in various shapes without fraying or raveling.*

Clear Plastics Coating for Brass, Aluminum

A clear epoxy-polyester coating has been designed for protecting the surfaces of treated and untreated aluminum, brass and other metal products. The producer, John L. Armitage & Co., 245 Thomas St., Newark, N. J., says the coating makes it possible to retain the original luster of the base metal.

The coating is said to have good resistance to marring, heat, cracking and staining. It is cured by baking 3 to 15 min at 350 F.

KEY NO. 607

Improved Creep Resistance Expands Use of Zinc Alloy

A zinc alloy, called Hydro T Metal, recently announced by Hydrometals, Inc., 405 Lexington Ave., New York 17, N. Y., is said to have increased creep resistance and a lower coefficient of expansion than that normally found in unalloyed or copper hardened zinc. Data from Hydrometals indicates that at 70 F, under a stress of 8,000 psi, it will take 714 days for the alloy to elongate one percent. A similar figure for unalloyed zinc is 1.5 to 1.9 days.

Properties of Hydro T Metal (0.5% copper, 0.12% titanium, traces of chromium and manganese) presented in the accompanying table are compared with other metals commonly used for architectural applications.

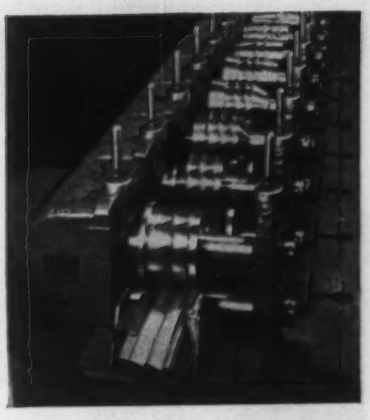
What are the applications?

Principal architectural applications

COMPARISON OF SOME PROPERTIES OF COMMON ARCHITECTURAL METALS

Metal →	T-Metal	Ordinary Zinc	Aluminum	Copper	Brass	18-8 Stainless
Avg Coef of Ther Exp, 10^{-6} in./°F	1.28	2.2	1.32	0.92	1.11	9.6
Density, lb/cu in.	0.258	0.258	0.0975	0.324	0.308	0.286
Melting Point, F	792	792	1200	1981	1750	2750
Spec Ht, Btu/lb/°F	0.096	0.092	0.214	0.092	0.090	0.118
Elec Cond, % IACS	27	30	50	100	26	2.1
Ther Cond, % of copper	34.5	34.5	46	100	32	4.0
Ten Str, 1000 psi	38	22	30	34	50	100
Elong (in 2 in.), %	20	32	11	45	40	50
Comp Weights (Zn=100)	100	100	37.8	125	119	111

Source: Hydrometals, Inc.



Yoder Roll-Forming Equipment mass-produces shapes accurately, economically

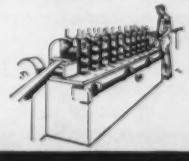
Yoder Roll-Forming Equipment, even with part-time operation, can effect significant savings in many metal working applications and industries. Shapes, simple or complex, can be quickly and economically produced the Yoder way from a wide variety of flat-rolled coated or uncoated stock ... in thickness up to ¾ inch ... in speeds up to 50,000 feet per day.

Yoder engineers flexibility and precision into metal forming operations. For example: many basic shape modifications, such as coiling, welding, notching, ring-forming, perforating, and cutting to length can be simultaneously accomplished with little or no additional labor cost.

Yoder also makes a complete line of Rotary Slitters and Pipe and Tube Mills. Profit from Yoder's years of engineering and service experience, contact your local Yoder representative or send for the Yoder Roll-Forming Manual.

This fully-illustrated 88-page book clearly discusses every important aspect of Yoder Roll-Forming Equipment and methods ... it's yours for the asking!

THE YODER COMPANY
5546 Walworth Avenue • Cleveland 1, Ohio



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COLD ROLL FORMING MACHINES

For more information, circle No. 341

"Here's a boxful of cost-cutting, product-improving ideas for you"

In versatility, performance and cost, Vulcanized Fibre may help crack your next design problem

For proof, look at this National product and its almost unbelievable range of uses. To name a few: delicate surgical instruments; rail joint insulation for railroads; clothes hampers for the home; dense, durable gears and cams; flexible backings for abrasive disks; arc chutes for lightning arrestors; motor insulation; punched tape for data processing machines; formed athletic guard equipment.

Among engineering materials you'll find National Vulcanized Fibre unique and surprisingly economical. It weighs only half as much as aluminum. It has unsurpassed arc resistance, low thermal conductivity, excellent resilience and high abrasion resistance. It absorbs sudden and repeated shock and impact without failure. And it is available in a fire resistant grade.

After 100 years, users are still finding new things they can do *to* Vulcanized Fibre. It can be machined, polished, painted, embossed, lacquered and combined with other materials, such as laminated plastic, aluminum, wood, rubber, asbestos or copper. It can even be formed or deep drawn into intricate shapes. Available in both standard and special forms and sizes.

Send for our special kit of samples (shown above)—write on your letterhead please—and evaluate the design possibilities personally. Let us know what use you have in mind. We'd like to help. National Vulcanized Fibre Co., Dept. KK-6, Wilmington 99, Delaware.

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at this time are leaders, gutters, and other roofing components. Others include door and window frames, decorative trim, terrazzo strips, ductwork, expanded metal lath, shingles and curtain walls. In other areas, automotive components (grills, covers, etc.), fasteners (zippers, nails), electric terminals and electronic component shields have been fabricated.

Available forms

Hydro T Metal is available in standard sizes of sheet and strip, and in extrusions; wire will be available soon. KEY NO. 640

Urethane-Base Coating Insulates up to 6000 F

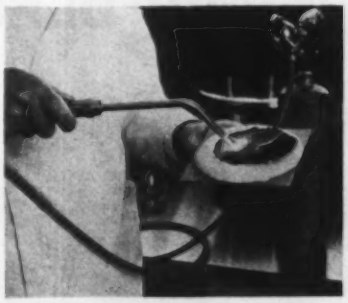
Wiring, instruments and other critical parts on a launching pad have been protected against the direct blast of a large missile by a new plastics coating. Previously, much of the wiring, instrumentation and other items on the pad had to be replaced after each launching.

Another use anticipated for the coating is as a fire barrier in aircraft and industrial plants.

Coating is intumescent

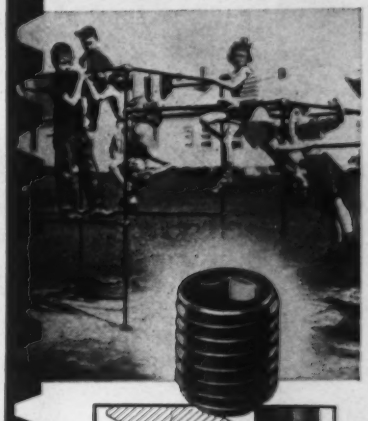
The coating, called D-65 and developed by Dyna-Therm Chemical Corp., 3813 Hoke St., Culver City, Calif., is a flame resistant, intumescent coating containing phosphates and boron flameproofing chemicals dispersed in a flexible polyurethane binder.

The intumescent coating swells and foams when exposed to a flame. The exposed surface of the coating



Heat resistance: *urethane-base coating protects panel against 4000 F flame.*

they're safe with **SETKO NU-CUP*** set screws on the job!



Whether it's supporting children on monkey bars or harnessing a spinning shaft you'll find NU-CUP set screws dig in deeper and hold tighter. The shaft illustrated here tells the story.

NU-CUP has a 42% sharper point which penetrates in a deep, full circle giving tremendous holding power. In some cases it actually reduces the number of set screws needed for the job.

You can get them in slabbed, slotted, hex or fluted socket.

SEND FOR FREE TEST SAMPLES and full information. Ask about NU-CUP set screws. Catalog 23 free on request.

*U.S. Pat. No. 2,778,265

SETKO Set Screw & Mfg. Co.

149 Main Street, Bartlett, Illinois

875

TIRES LAST LONGER
WHEN THEY'RE MADE WITH AMERIPOL
MICRO-BLACK

BETTER CARBON BLACK DISPERSION, MORE ABRASION RESISTANCE WITH AMERIPOL MICRO-BLACK ...THAT'S WHY TIRES LAST LONGER

Compare the uniformity of carbon black dispersion in Micro-Black with other formulas, as illustrated in the photomicrographs below. Micro-Black's micron-size particles are thoroughly dispersed in the rubber by an exclusive process—high liquid shear agitation at the latex stage. You get controlled uniformity, superior dispersion, greater abrasion resistance.

And WITH AMERIPOL MICRO-BLACK YOU SAVE FOUR WAYS!

1. **SAVE TIME**—The black is already in the rubber. You eliminate one weighing operation, one mixing operation, shorten other mixing operations!
2. **SAVE POWER**—Fewer mixing operations, shorter mixing cycles lower your power consumption!
3. **SAVE INVENTORY COSTS**—You handle and store only one material—Micro-Black—instead of two—rubber and carbon black!
4. **SAVE EQUIPMENT**—By eliminating the carbon black mixing operation, equipment is free for other uses. This means increased production without added investment!

NOW! A COMPLETE LINE OF 11 AMERIPOL MICRO-BLACKS

No matter what you manufacture, Goodrich-Gulf has the right Micro-Black masterbatch to meet your requirements.

CALL YOUR GOODRICH-GULF SALES ENGINEER . . . he'll help you determine the right recipe and proper grade of Micro-Black for your needs. He'll help you test it with the full cooperation of the Goodrich-Gulf Technical Sales Service Laboratory. Call or write us at 1717 East Ninth Street, Cleveland 14, Ohio. Plants at Port Neches, Texas, and Institute, West Virginia.

Goodrich-Gulf Chemicals, Inc.

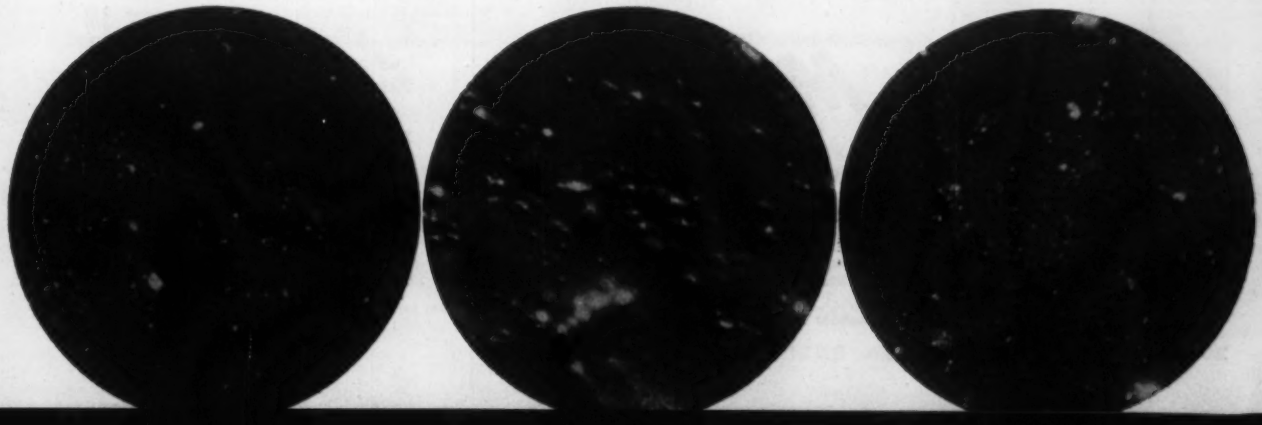
THE ONE TO WATCH FOR NEW DEVELOPMENTS

For more information, circle No. 485

Ameripol 4659. A high dispersion Micro-Black containing 52 parts HAF carbon black. Note uniform dispersion of black in the rubber.

Conventional dry mix masterbatch, containing 52 parts HAF carbon black.

Black masterbatch, containing 52 parts HAF carbon black, mixed by a competitive slurry method.

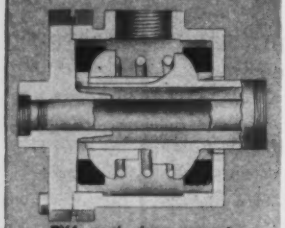


You can depend on

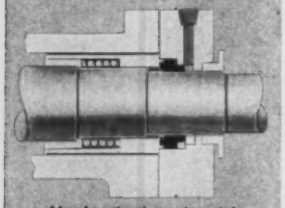
PY4

Morganite

SEALS



PY4 seal rings operate with highest efficiency in this rotary pressure joint carrying steam-condensate.



Mechanical seals with Morganite PY4 noses provide an extra measure of dependability in this stuffing box assembly.

Application tested for all sealing requirements

Service-proven on toughest assignments

LINK PY4 GRADE of self-lubricating MORGANITE is the engineer-preferred seal material for every application where premium performance is a "must." Actual service records compiled on PY4 Seals in all types of rigorous service, prove that this super-rugged material can take punishment! PY4 Seals function with highest efficiency in the presence of grease, searching liquids, corrosives, high pressures and high temperature. Install Morganite LINK PY4 for longer seal life . . . reduce down-time and save on seal replacement costs.

AVAILABLE WORLDWIDE—Send drawings and operating data for a recommendation on your specific seal requirements.

FOR OVER HALF A CENTURY...

Morganite INCORPORATED

TRADE MARK

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Manufacturers of Fine Carbon Graphite Products including Mechanical Carbons, Motor and Generator Brushes, Carbon Piles, Current Collectors and Electrical Contacts... Distributors of 99.7% Pure Al_2O_3 Tubes and Crucibles

For more information, turn to Reader Service card, circle No. 361

What's new IN MATERIALS

PROPERTIES OF D-65 COATING

Solids, %	30
Weight, lb/gal	8.2
Viscosity, cps	2500
Color	White
Reflectance, %	77
Flexibility	No cracking after bending over ⅛ in. mandrel
Elongation (min), %	300
Dielectric Strength, v/mil	97-130

forms a hard, ceramic-like crust that reflects heat. As the crust ablates away, the process of intumescence, i.e., foaming and swelling when exposed to flame, is repeated until the crust reaches the substrate.

In an actual demonstration, a 50-mil thick film of the coating insulated a reinforced plastics panel from a directly applied 4000 F acetylene flame for more than 1 min. And the developer says the new coating ". . . has proved effective in field tests under temperatures as high as 6000 F."

Dyna-Therm's D-65 coating is liquid with about 30% solids. It can be applied by spraying or brushing. The coating dries to the touch in 20 min and sets permanently in 18 hr. It has a shelf life of six months.

KEY NO. 608

Color-Coated Stainless Is Durable, Attractive

Two steel producers have recently placed color-coated stainless steel on the market for use in indoor and outdoor applications.

Chief advantage of the color-coated stainless steel is that it provides exceptionally long life in outdoor applications compared to coated carbon and low alloy steels.

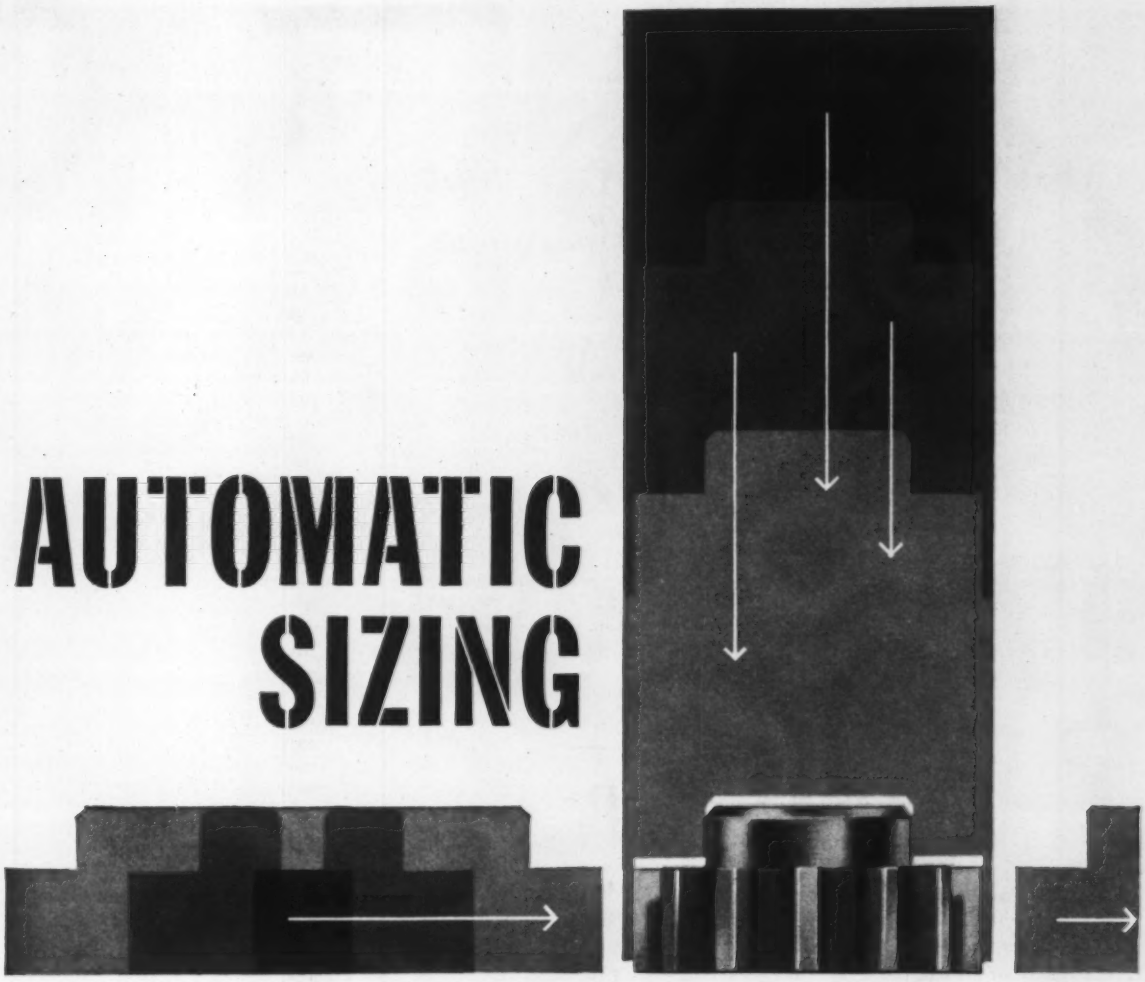
One producer, Washington Steel Corp., Washington, Pa., coats its stainless steel with an organic coating. The other producer, Allegheny Ludlum Steel Corp., Oliver Bldg., Pittsburgh 22, uses a chromate-type coating.

1. Organic-coated stainless

Washington Steel Corp. calls its color-coated stainless steel ColorRold.

Although the company has not revealed composition of the coating, it does say that it is a complex organic coating that is formulated by

AUTOMATIC SIZING



speeds production of powder metal parts

The photo illustrates a modified Stokes compacting press, Model T-4, equipped with a special holding and feeding fixture for automatic sizing. This type of rotating fixture has proved highly successful in sizing small, complex parts.

Stokes brings new thinking, new designs to high-speed sizing of powder metal parts. With speed, accuracy, and minimum tool wear as design objectives, Stokes has modified many of its standard compacting presses for automatic high-speed sizing. The Stokes presses now in service are sizing a wide variety of powder metal shapes at high production speeds . . . and they are easily converted to operate either as sizing or compacting presses.

For special applications, Stokes offers such production-oriented design considerations as automatic feeders, orientation and inspection devices, and other innovations. It is this kind of advanced thinking that can keep you ahead of rising production costs . . . can help you plan for your future needs.

Consult Stokes Engineering Advisory Service on your specific powder metal application. You'll get professional assistance in designing parts, punches and dies, or complete production facilities. Technical information on the complete Stokes line of compacting presses is available on request.

STOKES

POWDER METAL PRESS DIVISION • **F. J. STOKES CORPORATION** • 5500 TABOR ROAD, PHILADELPHIA 20, PA.

For more information, turn to Reader Service card, circle No. 481

RANSBURG

What Would Paint Savings Like This* Mean in YOUR Finishing Department?

Quality is all important in the production of fine Metalcraft furniture by George Koch Sons, Inc., Evansville, Indiana.

That's why they use the Ransburg Electrostatic Hand Gun to apply a uniform clear coating on their brass-plated furniture. The protective coating is baked on. Although the bulk of their present production is in the popular brass line, they still paint the metal furniture in a variety of colors with the Hand Gun.

Painting is CLEANER ... QUICKER ... CHEAPER *with the Ransburg Electrostatic Hand Gun.*

These chairs and table are typical of the Koch line of metal furniture.

*10 GALLONS OF PAINT NOW DOES THE JOB WHICH FORMERLY TOOK 30 GALLONS

On one item—a TV table—they formerly used 30 gallons of enamel to coat 1000 units by combination dip and air spray method. Now—with the Ransburg Electrostatic Hand Gun, they paint 1000 tables with only 10 gallons. And, they get a better, more uniform coating, too.

NO REASON WHY YOU CAN'T DO IT, TOO!

See how the Electrostatic Hand Gun can save time . . . paint . . . and cut costs in YOUR finishing department. Or, if your production justifies, it'll pay you to investigate Ransburg's automatic electrostatic spray painting equipment. Write for our No. 2 Process brochures which show numerous examples of modern production painting in both large and small plants.

RANSBURG

RANSBURG
Electro-Coating Corp.
Box-23122, Indianapolis 23, Indiana

For more information, turn to Reader Service card, circle No. 412

dissolving proprietary resins in organic solvents. The coating is then applied to stainless steel and baked at moderate temperatures. Baking is said to form a thermosetting film of exceptional durability on stainless steel.

In actual production, sheets or coils of stainless steel are fed through high speed coating equipment capable of producing accurate coating thicknesses of from ½ to 2 mils.

The producer says the coated steel can be sheared, blanked, bent, perforated, stamped and deep drawn without damaging the coating.

Properties: Tests show ColorRold resists a wide variety of acids, lubricants and cleaners. Other tests show it has good resistance to thermal shock, high humidity, abrasion and wear. The product can be used at temperatures up to 350 F.

Uses: The color-coated steel is expected to be used for kitchen equipment, door frames, awnings, canopies, curtain wall panels, facades, hoods, elevator doors, marquees, numerals, soda fountains, spires, telephone booths, vault linings, window frames and wall tiles.

The coated stainless steel is supplied in smooth or textured surfaces in all popular gages and widths.

2. Chromate-coated stainless

Allegheny Ludlum says its color-coated stainless steel is produced by spraying, brushing or rolling a chromate-base coating on stainless steel, then baking at 350 F. According to the producer, the coating process requires no unusual pretreating, no primer undercoat, and no baking at extremely high temperatures.

The coated steel is said to have an evenly colored surface that is attractive, durable, and abrasion and corrosion resistant.

A big use for the new material will probably be curtain walls for outdoor applications. Other uses are kitchen and laundry appliances, auto trim, wheel covers, serving trays,

SOURCES of most engineering materials can be found in the third edition of M/DE's *Materials Selector* reference issue, published last October. Properties of all materials are also given.

What every designer should know about

High nickel alloy hot wound springs for high temperature service

For high temperature service in nuclear power plants, steam turbines and boilers, petrochemical plants and other industrial applications, large compression springs are needed. They can be hot wound from rod 3/8 inch in diameter — or larger.

Resistance to relaxation at temperatures up to 1000°F plus economy are the most important factors in such service. From these overall standpoints and for corrosion resistance, Inconel "X"* nickel-chromium alloy is perhaps the most practical metal for hot wound springs:

- **It can be direct age hardened (16 hours at 1350°F) for useful service at temperatures up to 1050°F. Or down to −320°F — or lower.**
- **It has outstanding resistance to corrosion or oxidation . . . is especially resistant to strong oxidizing acids . . . has excellent resistance to alkaline corrosives.**
- **In the large rod sizes used for hot coiling, it actually costs less than many other high temperature spring materials.**

Inconel "X" alloy is easily worked, too. An Inconel "X" spring can be hot set and then age hardened... will respond consistently to the heat treatment, with practically no distortion.

Additional Alloys for Hot Wound Springs

"K" Monel* alloy — a non-magnetic nickel-copper alloy with strength and hardness comparable to heat-treated alloy steels. Its corrosion resistance and ductility are similar to those of Monel* nickel-copper alloy.

Duranickel* — an age-hardenable Nickel which can be treated after machining and forming. Highly corrosion-resistant . . . stronger and harder than "K" Monel alloy... often used for plastic extrusion equipment.

Helpful new Technical Bulletin T-35, "High Nickel Alloy Helical Springs," gives detailed design, fabricating and specifying information on Inconel "X" alloy, Duranickel, "K" Monel alloy and other useful age-hardenable materials for hot wound springs. It's yours for the asking. *Inco trademark

HUNTINGTON ALLOY PRODUCTS DIVISION
The International Nickel Company, Inc.
Huntington 17, West Virginia

INCO TRADE MARK **ALLOY PRODUCTS**

For more information, turn to Reader Service card, circle No. 492

United States Testing Company offers a

NEW CALIBRATION SERVICE

for
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You can meet government accuracy requirements... and get fast, one-stop calibration service in our Calibration Laboratory. Here's what you get:

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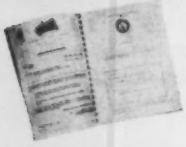
Ask about our Contract Calibration Service where we keep calibration records and remind you of due dates. If you are in the metropolitan area, our In-Plant Calibration Service can prevent a production stoppage. Why not write or phone for a calibration service to meet your needs.

12



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The World's Most Diversified Independent Laboratory.

UNITED STATES TESTING CO., INC.

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coffee makers, refrigerator doors and trim, acoustical tiles, hardware and furniture. KEY NO. 609

Polypropylene Blocks for Prototype Use

Polypropylene blocks, rods and cylinders are now available for prototype applications, such as appliance housings, valves, automotive parts and laboratory ware. The supplier, American Agile Corp., P. O. Box 168, Bedford, Ohio, says the heavy, semi-finished moldings can be easily machined, ground, drilled, threaded and welded on standard shop equipment.

Prototypes made of the polypropylene parts can be used for in-plant or field testing, and for customer approval prior to production tooling.

Blocks are supplied in sizes ranging from 1 by 12 by 12 in. (4.7 lb), to 3 by 12 by 24 in. (28.2 lb). Prices range from $11.75 to $63.45 per block.

Rods are available in 2 and 4-in. lengths in diameters from ½ to 3 in.: cylinders in sizes from 4 to 6-in. o.d. by 2-in. i.d. Prices of rods and cylinders range from 60¢ to $27.75.

KEY NO. 610

Paper-Base Tubing Is Crack-Free, Strong

A new, thick-walled paper-base tubing is available for such electrical applications as lightning arrester barriers and fuse tubes. For such uses the tubing is said to be equivalent in performance to cloth-base materials.

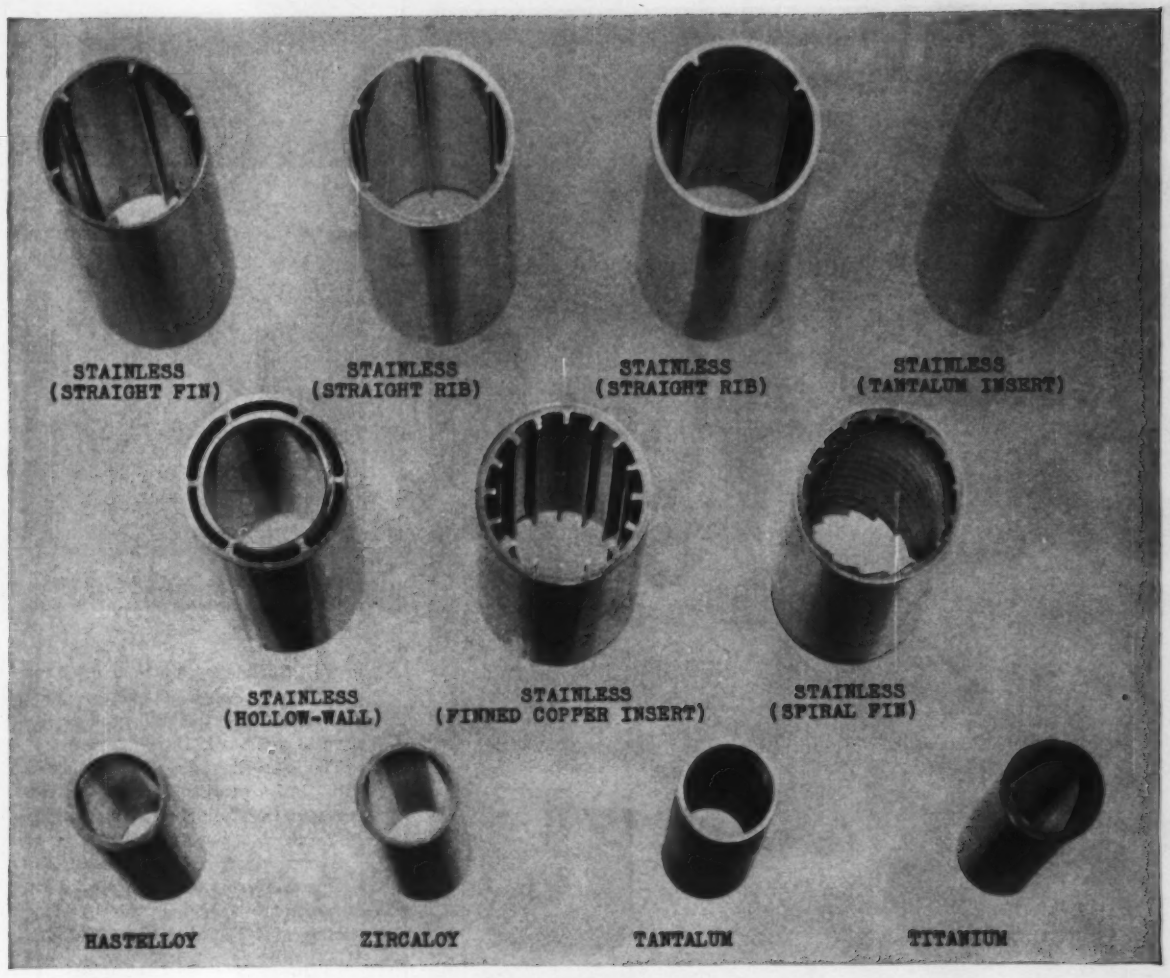
The tubing, designated Grade 20005, was developed by Westinghouse Electric Corp., Micarta Div., Hampton, S. C.

Advantages

A big advantage of the material is that it is guaranteed crack-free

PROPERTIES OF GRADE 20005 TUBING

Moisture Absorption, %	1.0
Compressive Strength, psi	21,000
Tensile Strength, psi	12,000
Dielectric Strength (short-time), v/mil	500
Dissipation Factor (1 mc)	0.045



ALL OF THESE TUBES WERE PRODUCED by a remarkable new process called FLO-ROL

Tubes like these have never been economically available before. The entirely new process, known as FLO-ROL, will produce a wide variety of internal configurations, in high cost alloys, stainless steel, and other hard-to-work metals, plus many bi-metal and tri-metal combinations. Wall tolerances for FLO-ROL tubing can be held to ±.0005" and diameters to ±.002" depending on sizes.

- *Internally Finned Tubes* offer increased surface for more rapid heat transfer.
- *Bi-Metal Tubes*—stainless steel tubes with tantalum, zirconium, or other expensive material offer exceptional corrosion-resistant qualities without the prohibitive cost.
- *Hollow Wall Tubes* or barrier tubes are available in several designs for nuclear work or other special applications where a chambered tube is essential or desirable.
- *Thin Wall Tubes* for pneumatic lines are available with .015" wall or lighter.

FLO-ROL precision tubular products can be furnished from ½" to 2½" O.D. and, in some instances, in lengths up to 75'. For complete information contact your nearest Damascus representative or write direct. For prompt service send prints and specifications—we will be happy to work with you.

Send for new FLO-ROL PRECISION TUBE BULLETIN TODAY

DAMASCUS TUBE COMPANY

STAINLESS STEEL TUBING AND PIPE

GREENVILLE, PENNSYLVANIA

For more information, turn to Reader Service card, circle No. 466

A decade has passed since Tinius Olsen introduced the SelecTrange Dial Indicator — the electronic null balance system that has literally revolutionized the design and use of universal and torsion testing machines. As the heart of all Super "L" and ElecTmatic units, it still stands out as the most accurate and flexible load indicating system ever developed.

But that is only a part of the SelecTrange story. Its basic principles have been the springboard to a full line of strain detecting instruments, recorders, automatic controls, etc. These are advancing modern materials technology from determining the modulus of thin plastic films to studying the characteristics of exotic metals at elevated temperatures.

For an informative brochure on the impact of SelecTrange and its related developments on industry, and their importance to you, send today for a copy of Tinius Talks, Vol. 12, No. 2.

TINIUS OLSEN
TESTING MACHINE COMPANY
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Testing and Balancing Machines

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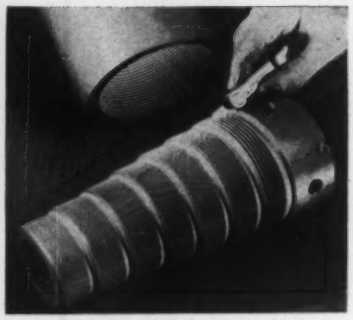
For more information, turn to Reader Service card, circle No. 480

What's new IN MATERIALS



***Thick-walled tubing** can be threaded with as many as 28 threads per in.*

in wall thicknesses up to 1 in. Other advantages: high strength, good electrical properties and good resistance to moisture.

The material is readily machined with conventional equipment, and can be tapped or threaded with as many as 28 threads per in.

According to Westinghouse, the tubing conforms to performance requirements specified for molded tubing of NEMA grade XXX and MIL-P-79B type PBF. KEY NO. 611

High Purity Nickel for Electron Tubes

Metallurgical research by K. M. Olsen of Bell Telephone Laboratories, Inc., 463 West St., New York 14, has produced nickel cathode materials of such high purity that undesirable thermionic characteristics associated with certain impurities have been largely eliminated.

The nickel is used in the form of strips in vacuum tubes. When the nickel strips are heated they emit electrons. Impurities in the nickel determine the level of electron emission and length of time a given emission level can be maintained.

Olsen says as little as 0.01% (by weight) of such impurities as magnesium, carbon and silicon markedly influence emission properties.

How strips are made

The new high purity nickel strips were prepared as follows:

1. Nickel powder was sintered to form nickel slugs by a wet hydrogen treatment at low temperatures. This

1 HOM, a new alloy developed by Duraloy metallurgists and capable of retaining high working strength at temperatures up to 2200°F, with limited application at 2300°F. The alloy is applicable for all types of castings: static, centrifugal, shell-molded.

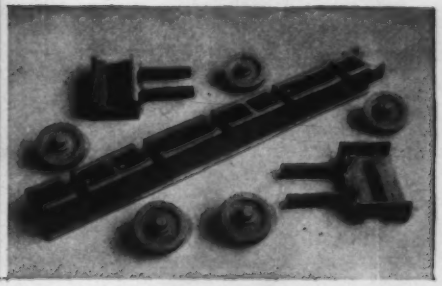
2 Shell-molded castings for meeting close and rigid tolerance limits; post-casting machining or other finishing practically eliminated; low mass production costs.

Illustrating 4 of Duraloy's Major Casting Services

If the casting used in your equipment has to meet high temperature (anything up to 2300°F) and/or corrosion, why not discuss your requirements with our metallurgical staff? Our company can call upon more than 35 years of experience in this exacting business of high alloy castings. In the meanwhile, if you would like to have a copy of our latest catalog, write or call our nearest office.

3 Centrifugal castings which produce a denser, more uniform metal approaching forged metal strength.

4 Static castings which can be produced in weights ranging from a few ounces to single castings 7 tons and heavier; wide range of alloying combinations, including the new HOM referred to above.



Note

As a point of interest, all of the castings shown here were produced for Lindberg Engineering Company, Chicago, for incorporation in heat-treating and annealing equipment sold by that company. The centrifugally cast tube for the generator, trays, and rollers for the furnace rails are cast of HOM. The rails and rail supports for the furnace are statically cast of 35-15 alloy.

ALLOY CASTING INSTITUTE ACI MEMBER

DURALOY Company

OFFICE AND PLANT: Scottdale, Pa.
EASTERN OFFICE: 12 East 41st Street, New York 17, N. Y.
CHICAGO OFFICE: 332 South Michigan Avenue
DETROIT OFFICE: 23906 Woodward Avenue, Pleasant Ridge, Mich.

For more information, turn to Reader Service card, circle No. 369

For almost every hardness testing requirement

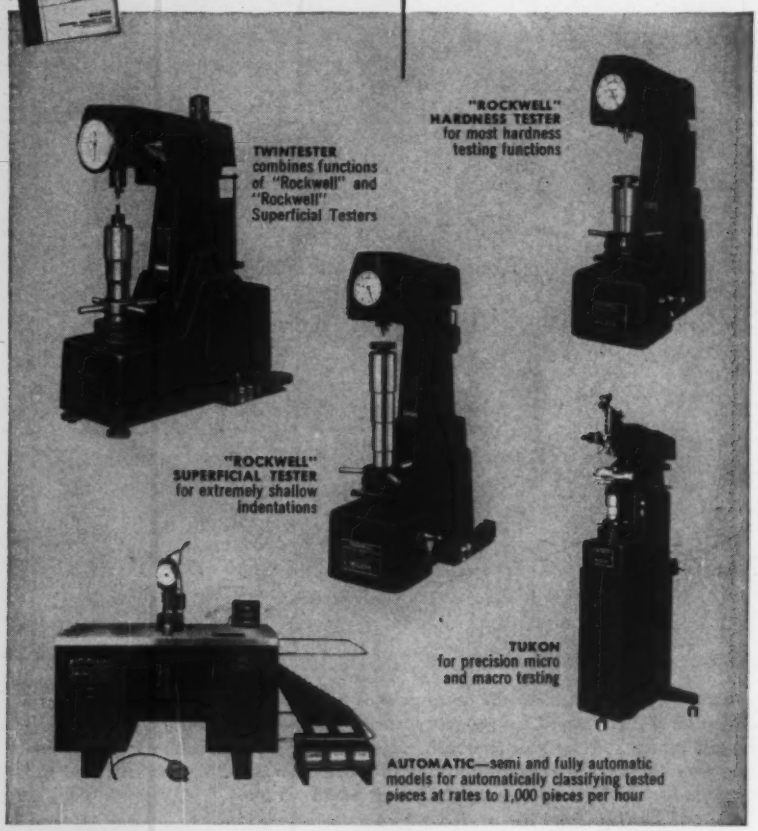
There's a Wilson "Rockwell" instrument to do the job

Wilson "Rockwell" Hardness Testers can help make your products better, stronger, longer lasting. They give reliable results on the production line, in laboratories, in tool rooms, and in inspection departments. They're as easy to use as a center punch, as durable as a machine tool, as sensitive and accurate as a precision balance. That's why Wilson "Rockwell" is recognized as the world's standard of hardness testing accuracy.

Wilson "Brale" Diamond Penetrators give Perfect Readings

A perfect diamond penetrator is essential to accurate testing. Only flawless diamonds are used with Wilson "Brale" penetrators. Each diamond is cut to an exact shape. Microscopic inspection and a comparator check of each diamond—one by one—assure you of accurate hardness testing every time.

Write for Catalog RT-58. It gives complete details on the full line of Wilson hardness testing equipment.


TWINTESTER
combines functions of "Rockwell" and "Rockwell" Superficial Testers
"ROCKWELL" HARDNESS TESTER
for most hardness testing functions
"ROCKWELL" SUPERFICIAL TESTER
for extremely shallow indentations
TUKON
for precision micro and macro testing
AUTOMATIC—semi and fully automatic models for automatically classifying tested pieces at rates to 1,000 pieces per hour

WILSON "ROCKWELL" HARDNESS TESTERS

Wilson Mechanical Instrument Division
American Chain & Cable Company, Inc.
230-E Park Avenue, New York 17, New York

ACCO

For more information, turn to Reader Service card, circle No. 417

step reduced oxygen and carbon content.

2. The sintered slugs were then melted in dry hydrogen in a controlled atmosphere furnace. During melting, a steady flow of hydrogen was maintained. After the charge reached a temperature of 2700 F, the dry hydrogen was purged with dry helium, and all gases were removed by evacuation.

3. Next, dry hydrogen was reintroduced to effect a further reduction of carbon and oxygen in the melt. The hydrogen was purged again with helium and both gases were removed by evacuation. Helium was then reintroduced. Ingots produced in this manner weighed 26 lb and were 1½ in. thick.

4. The ingots were hot rolled in air at 1800 F to a thickness of ½ in. The surface was then machined to remove oxide scale. Cold rolling was used to reduce the thickness further.

5. The strip was then annealed at 1500 F in hydrogen. After annealing, the strip was cold rolled, annealed again, and finally rolled to a finished strip having a thickness of 0.003 in.

Details of Olsen's work are given in the Feb '60 issue of *Bell Laboratories Record*.

Expanded Polyolefins for Decorative Grids

Expanded polyethylene and polypropylene plastics sheets are now available for use as decorative grids, wastebaskets, playpens, filter grids, flooring, boat hammocks and athletic backstops.

The sheets, supplied in 22 and 24-in. widths, are available from Reeves Bros., Inc., 1071 Avenue of the Americas, New York 18. Nominal widths of 36, 42 and 48 in. are planned. Price is 15¢ per sq ft.

The expanded plastics sheeting has a breaking strength of 40 psi and an elongation of 10 to 15%. The material can be stabilized against degradation by ultraviolet rays, making it suitable for outdoor use.

Expanded polyolefin plastic begins as a flat strip extrusion ¼ in. thick and 10 in. wide. It is then flattened

NEW SUPER STAINLESS STEELS SHED CORROSION

PH55A and PH55B are the new super stainless steel alloys developed by Cooper Alloy Corp. to resist those corrosion-erosion, corrosion-abrasion attacks which cannot be handled by most extisting alloys.

These alloys have high strength and high hardness even at temperatures elevated to 1000°F-1400°F. PH55A is particularly recommended for applications where pitting corrosion is the problem. PH55B, more ductile, is suited for applications where corrosion resistant parts are subject to stress and shock. Write today for Form PH55.

COOPER ALLOY

Corporation • Hillside, New Jersey

For more information, turn to Reader Service card, circle No. 452

which stack
would YOU use for
corrosive fumes?
8888-CC
This stainless steel stack failed after only 6 months in corrosion service!
Over 2 years old . . . yet this Duracor stack shows absolutely no signs of attack inside or outside!

DURACOR VENTILATING SYSTEMS PROVIDE LASTING CORROSION RESISTANCE AT LOW COST!

Performance-proven Duracor Ventilating Systems and components provide outstanding resistance to attack from all types of corrosive fumes. These high-strength systems are corrosion-proof throughout . . . are practically immune to weathering . . . require only minimum support! Best of all, Duracor construction can save you up to 30% on your initial investment . . . and it's maintenance-free! Ceilcote engineers will design a complete Duracor system to meet your special requirements . . . or modify your present system to permit gradual conversion to Duracor. Fabricated to meet customer specifications . . . or assembled from stocked component parts . . . Duracor Ventilating Systems can be easily installed by regular plant maintenance crews or by experienced Ceilcote installation personnel. Write today for the new Ceilcote catalog.

DURACOR CEILCOTE

ANOTHER PRODUCT OF

THE CEILCOTE COMPANY, INCORPORATED

4899 Ridge Road • Cleveland 9, Ohio

For more information, turn to Reader Service card, circle No. 378

and perforated with slits staggered like courses of brick. When the material is pulled at right angles to the slits it opens up into a web or netting. KEY NO. 612

New Tapes Used for Insulating, Sealing

Eleven new tapes have been introduced in recent months for a variety of electrical and industrial applications. Five of the tapes are made of TFE resin and three of glass cloth. The others are silicone rubber, nylon and polyethylene.

1. Five TFE tapes

An electrical tape called Scotch brand No. X-1111 has been introduced by Minnesota Mining & Mfg. Co., 900 Bush Ave., St. Paul 6, Minn. The tape has a 0.002-in. thick backing of extruded TFE film coated on one side with a pressure sensitive adhesive. The adhesive tape is said to have good resistance to jet fuels and hydraulic fluids. It also has good tack and heat resistance. The tape is recommended for use at Class F (310 F) temperatures. KEY NO. 613

Irvington Div. of 3M has introduced a TFE tape for sealing and lubricating threaded and coupled pipe joints. It is called No. 4212. The tape is supplied in ½-in. widths, and in lengths of 260 and 520 in. KEY NO. 614

Permacel, Inc., U. S. Hwy. No. 1, New Brunswick, N. J. has introduced a pressure sensitive TFE tape called No. 423. It is designed for

***TFE tape** developed by Irvington Div. of 3M can be used for sealing and lubricating threaded pipe joints.*

size is no problem!

The bigger your tubular steel problem – the better we like it! Why? Because with all our modern facilities "under one roof," we are completely equipped to handle a variety of difficult jobs – expertly and economically! For expert consultation on centrifugally spun tube applications in your field... call on ACIPCO.

VERSATILE ACIPCO CENTRIFUGALLY SPUN STEEL TUBES

SIZE RANGE: Lengths up to 40 feet to meet modern machinery requirements have been produced. O.D.'s from 2.25″ to 50″; wall thicknesses from .25″ to 4″.

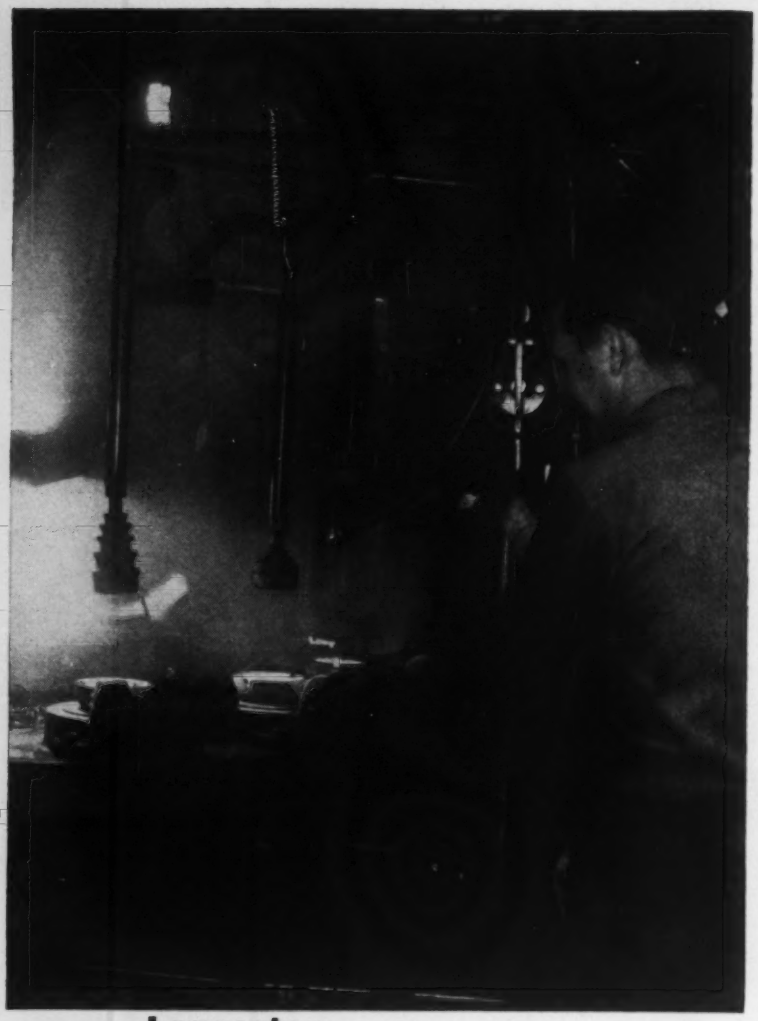
ANALYSES: All alloy grades in steel and cast iron, including heat and corrosion resistant stainless steel, plain carbon steel and special non-standard analyses.

FURNISHED: As cast, rough machined, or finished machined, including honing. Complete welding and machine shop facilities for fabrication.

Write for FREE Illustrated Catalog.

ACIPCO
SPECIAL PRODUCTS
DIVISION OF AMERICAN CAST IRON PIPE CO.
BIRMINGHAM • ALABAMA

For more information, turn to Reader Service card, circle No. 447



Lancaster mass production reduces the cost of your glass parts . . . and assures you of uniform high quality from first to last. When you order glass components from Lancaster, you get a firm delivery date based on immediate scheduling. And Lancaster produces your parts with the method that means lowest possible unit cost: automated machines for large orders, efficient hand work for smaller runs. (Equipment shown above produces parts from crystal, colored and lead glasses or moonstone.) Lancaster design experience and production facilities are at your disposal — no matter what type of glass or process your part requires. Call OLive 3-0311 for information or send blueprints for quotations. **LANCASTER GLASS CORPORATION, LANCASTER 7, OHIO.**

Lancaster®

glass and plastics to brighten your product's future

For more information, turn to Reader Service card, circle No. 405

Class H (360 F) electrical applications. The tape can also be used as an antifriction lining on heat sealing machinery, conveyor belts and chutes. **KEY NO. 615**

A reinforced TFE wrapping tape known as "Rulon Abrasion Barrier" is being offered by Dixon Corp., Bristol, R. I. It is recommended for insulating electrical wires rated for 500 F and higher temperature service. The tape is available in thicknesses down to 0.004 in., and in widths from ¼ to 12 in.

KEY NO. 616

Dixon Corp. also offers a very thin (0.001 in. thick) TFE tape for insulating wire. The producer says the tape is particularly suited for use on thermocouple wire and other constructions where cable size and weight must be minimized. The thin TFE tape is supplied in widths from ⅜ to 12 in. **KEY NO. 617**

2. Three glass cloth tapes

Permacel, Inc. (address above) has also introduced a silicone rubber-coated glass cloth tape called ES 5111. It is designed for use as a wrapping on motor coils. One side of the tape is fully cured, the other side uncured. The developer says this type of construction gives the tape long shelf life. **KEY NO. 618**

Minnesota Mining (address above) is marketing a TFE-impregnated glass cloth tape called Scotch brand No. X-1112. The tape is coated with a thermosetting silicone adhesive. It is recommended for use at Class H (360 F) temperatures. **KEY NO. 619**

A polyester-treated glass cloth tape has been developed by Micarta Div. of Westinghouse Electric Corp., Trafford, Pa. for Class B (265 F) service. The tape can also be used at higher temperatures for short periods of time. The nonmagnetic tape has a yield strength of 140,000 psi and a dielectric strength over 400 v per mil. **KEY NO. 620**

3. Nylon tape

A new nylon tape is designed to eliminate or reduce friction between two surfaces such as cabinet drawers. The pressure-sensitive tape, called Nyl-O-Tape and developed by Hardware Designers, Inc., South Hackensack, N. J., bonds to wood, metal, plaster and plastics surfaces. The tape is supplied in ¼, ⅜, ½,

KNOW YOUR ALLOY STEELS . . .

This is one of a series of advertisements dealing with basic facts about alloy steels. Though much of the information is elementary, we believe it will be of interest to many in this field, including men of broad experience who may find it useful to review fundamentals from time to time.

Normalizing Alloy Steels

There are several forms of heat-treatment commonly employed in the processing of alloy steels. Each in its own way modifies the mechanical properties and structures of steel, and each is chosen with a definite objective in mind. The five usual forms of treatment are normalizing, annealing, spheroidize-annealing, quenching and tempering, and stress-relieving.

In this particular discussion, let us consider briefly the purposes and effects of normalizing.

Normalizing is an operation in which the steel is heated to approximately 100 deg F above the upper transformation range, then cooled in still or agitated air. The basic purpose is to refine the prior structure produced by variations in finishing temperatures encountered in rolling or forging. The structure resulting from normalizing, being more uniform, will help create improved mechanical properties when the steel is subsequently reheated, liquid-quenched, and tempered.

There are times when large steel parts (heavy forgings, for example) cannot be liquid-quenched because of their size. In cases of this nature, the heat-treatment must consist of single or multiple normalizing followed by tempering.

High-temperature normalizing is sometimes used for grain-coarsening low-carbon alloy steels to promote machinability. (In high-temperature normalizing, steel is heated to more than 100 deg F above the upper transformation range.) At times it is possible to machine a steel in the air-cooled condition, the governing factor being the alloy content. However, the highly alloyed analyses may require annealing or tempering after normalizing, to decrease the hardness.

It is essential, when normalizing is employed, that free circulation of still or agitated air be provided. When air-cooling of individual bars or forgings is not practicable, the furnace charge should provide for some means of separation, such as racks or spacers.

If you would care to know more about normalizing, or any other phase of heat-treating, you are invited to consult with Bethlehem metallurgists. They are always glad to give you any help you need.

And remember that Bethlehem makes the full range of AISI standard alloy steels, as well as special-analysis steels and all carbon grades.

This series of alloy steel advertisements is now available as a compact booklet, "Quick Facts about Alloy Steels." If you would like a free copy, please address your request to Publications Department, Bethlehem Steel Company, Bethlehem, Pa.

BETHLEHEM STEEL COMPANY, BETHLEHEM, PA.

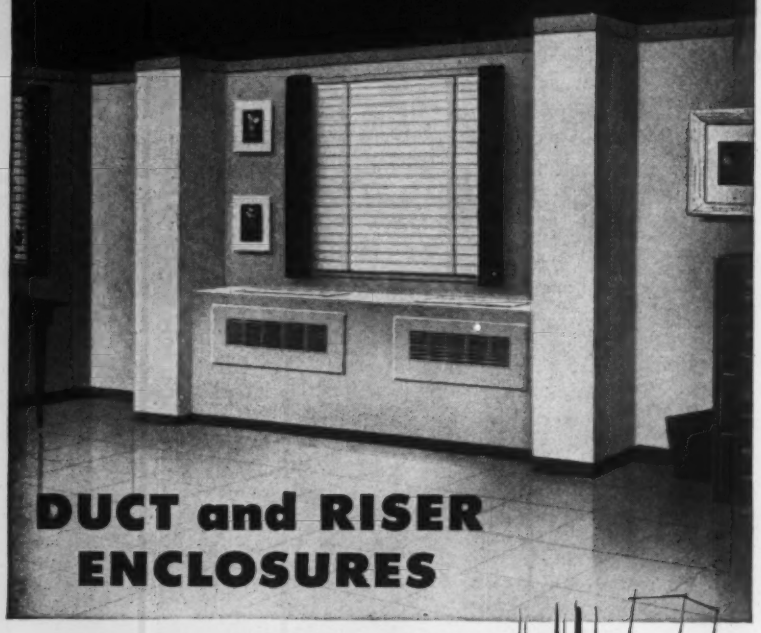
Export Distributor: Bethlehem Steel Export Corporation

BETHLEHEM STEEL

For more information, turn to Reader Service card, circle No. 320

MET-L-WOOD

METAL BONDED TO PLYWOOD



DUCT and RISER ENCLOSURES

... faster, cleaner installation

... lasting finished beauty

... complete accessibility

Installing Met-L-Wood riser enclosures, air ducts, convector covers and paneling benefits everyone connected with the job:

Architects and contractors plan on substantial installation time savings and know that smooth, uniform Met-L-Wood needs only paint to finish after installation.

Building management not only gets a clean, durable installation, fast; but is also assured of low-cost accessibility to pipes and other equipment without enclosure replacement expense.

Met-L-Wood units are pre-formed, ready to install with minimum labor. When finished, Met-L-Wood sections match perfectly with conventional walls and ceilings.

Whether you plan new construction or remodeling, write for literature now and learn all the advantages and economies you gain with Met-L-Wood.

MET-L-WOOD® CORPORATION

6755 W. 65th Street
Chicago 38, Illinois

For more information, turn to Reader Service card, circle No. 422

What's new IN MATERIALS

¾ and 1-in. widths. KEY NO. 621

4. Polyethylene tape

A pressure sensitive polyethylene tape for wrapping joints of plastics-coated steel pipe has been introduced by Republic Steel Corp., Steel & Tubes Div., 224 E. 131st St., Cleveland 8. Called X-Tru-Tape, the tape protects the exposed ends of plastics-coated pipe which is supplied "cut back" to permit welding. The tape is available in 1, 2 and 4-in. widths and in 100-ft lengths. KEY NO. 622

5. Silicone rubber tape

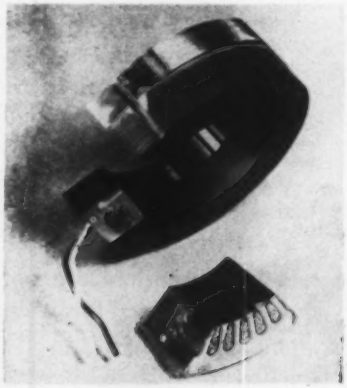
A self-bonding, unsupported silicone rubber tape is available from Permacel, Inc. (address above) for insulating wound motor coils. Called PSR-2800, the tape is designed for Class H (360 F) service. Although primarily a coil wrap, the tape can also be used for field repairs of Class H electrical equipment, and for wrapping busbars and complex cable harnesses. KEY NO. 623

Two Epoxy Resins for Casting, Laminating

New epoxy resins on the market include a shock resistant casting resin developed by Houghton Laboratories, Olean, N.Y., and a laminating resin developed by Furane Plastics Inc., 4516 Brazil St., Los Angeles 39.

1. Casting resin

Houghton's epoxy casting resin, called Hysol 6622, is designed especi-



***Stators** and transformers can be embedded with Houghton's new epoxy casting resin.*

PERFECT SEALS OF METAL TO GLASS
keep this Radar System on Track

Hundreds of components in this radar system—tubes, connectors, thermal relays, transistor stems, etc. contain seals of metal to glass. These seals are made possible by special metal alloys having the same expansion coefficient as glass.

At Bishop we have been making glass-to-metal sealing alloys in tubular and composite wire form for many years. In addition, we produce stainless steel and nickel tubing in mechanical, aircraft, capillary and hypodermic grades in sizes up to 1 inch OD—plus an amazing variety of "specialties" such as clad metals, super and "exotic" alloys.

We also produce a vast line of platinum products and chemicals that have been used by industry for over a century.

We are unique because of our ability to *work these metals to such tiny, precise forms.* Bulletin No. 12 describes our tubular products—Catalog No. 5 describes our platinum products. Write for them.

BISHOP

Tubular Products Division **J. BISHOP & CO.** *platinum works* 40 KING STREET, MALVERN, PENNA.

A JOHNSON MATTHEY ASSOCIATE "METALS FOR PRECISION AND PERFORMANCE"

For more information, turn to Reader Service card, circle No. 401

First cost doesn't measure true value

Take a high alloy casting designed for severe service. Two suppliers quote from the same drawing – same configuration, same composition: One supplier – with no proven background in high alloy work – quotes an apparently lower price than the other.

Should you grab the low-price supplier without investigating? Producing a heat or corrosion resistant casting that stands up is not just a matter of "making a pattern and pouring metal". It is a matter of:
(1) proper alloy control;
(2) foundry techniques adapted to the job;
(3) personnel who know best current practices and who understand casting design.

The moral: Be sure you are dealing with an experienced high alloy foundry.

ALLOY CASTING INSTITUTE
1001 Franklin Ave./Garden City, New York
... For technical information on corrosion resistant and heat resistant castings

May we send you the new ACI Technical Publications List and the 1960 List of Alloy Designations? Both free for the asking.

What's new IN MATERIALS

PROPERTIES OF EPOCAST 28 LAMINATES[a]

PHYSICAL PROPERTIES	
Specific Gravity	1.88
Flammability	Self-extinguishing
Water Absorption, %	0.07
MECHANICAL PROPERTIES	
Flexural Strength, psi	
Room Temperature	73,000
160 F	70,000
Compressive Strength, psi	52,000
Mod of Elast, 10^6 psi	4.1
Barcol Hardness	98

[a]Glass-reinforced laminate (resin content 31.4%) press cured ½ hr at 250 F at 25 psi, then postcured 3 hr at 250 F.

ally for embedding electric motor stators and transformers. According to the developer, Hysol 6622 epoxy castings containing large steel inserts do not crack after cycling at temperatures between –85 F and 300 F. KEY NO. 624

2. Laminating resin

Furane's laminating resin, called Epocast 28, is said to have the following advantages:

1. Long pot life.
2. Short cure at moderate temperatures.
3. Good resistance to ethylene glycol, MIL-0-5606 hydraulic oil, anti-icing fluid and MIL-H-3136 hydrocarbon fluid. KEY NO. 625

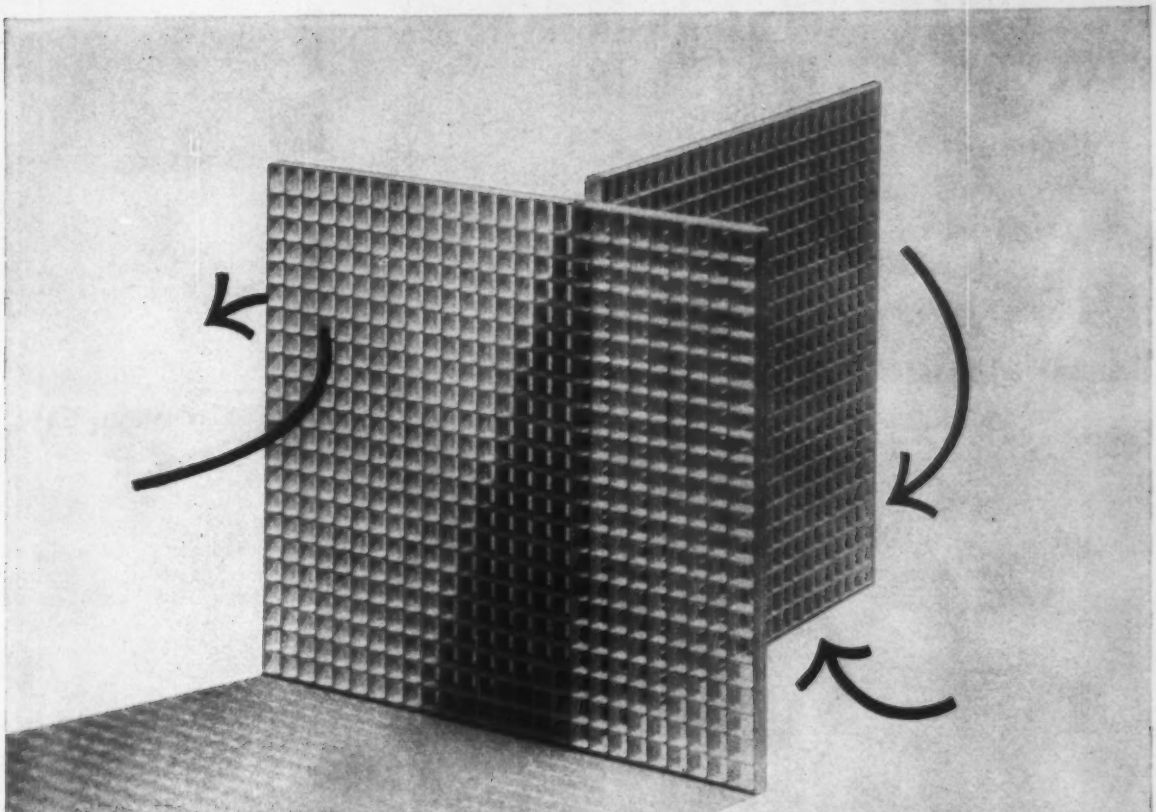
High Strength Steel for Heavy Duty Parts

Railroad car frames, truck bodies and related vehicles requiring high strength but only moderate corrosion resistance are some of the potential uses for a new high strength, low alloy steel developed by Armco Steel Corp., Middletown, Ohio. Other uses include construction and industrial equipment.

Corrosion resistance of the alloy, called No. 5, is said to equal that of copper-bearing mild steel. Fabrication in the as-rolled condition is limited to simple bending across the rolling direction and very light flanging and forming operations. Welding is done by common methods without pre- or post-heating.

The material meets requirements of SAE 950 and ASTM A-242-55. The alloy is supplied as hot-rolled

For more information, turn to Reader Service card, circle No. 355



This molded plastic light diffuser is non-combustible...meets new fire codes

The Guth Gratelite Louver Diffuser, molded in 2′ x 2′ modular units, provides a ceiling of glareless, shadowless light. But it is necessary that it be non-combustible in order to meet certain fire code ordinances.

This intricate molding problem was solved by the development of a special thermosetting urea plastic which would flow easily for the compression molding of the ⅜″ cubical openings and still retain the required light diffusion qualities.

Approved by Underwriters Laboratories, accepted and recommended by architects and lighting engineers, the Guth Gratelite Louver Diffuser is meeting with tremendous success.

This is another CMPC "White Gloves" molding. For maximum protection against material contamination, this product was molded under highly controlled production conditions involving special dust control measures and a protective materials handling system. This is another example of CMPC's specialized techniques and facilities for producing the best in molded plastics.

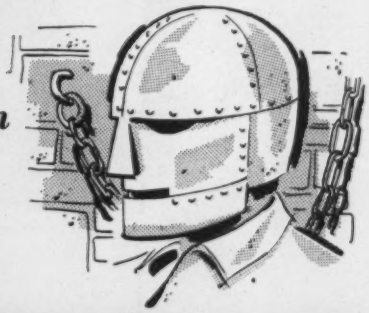
CMPC

CHICAGO MOLDED PRODUCTS CORPORATION
1020 F North Kolmar Avenue
Chicago 51, Illinois

For more information, turn to Reader Service card, circle No. 327

THE "MAN IN THE IRON MASK" WOULD HAVE PREFERRED

lightweight
non-corrosive
flexibility of design



INSUROK®

Laminated Plastics

one of our 52 grades would have done the job better.

Main Characteristics and Advantages: INSUROK is non-corrosive, remarkably strong and durable, readily machinable, chemically-inactive, highly dielectric, non-hygroscopic, and resists moisture and heat. Usually it requires no additional protective or decorative finish. It is half the weight of aluminum and a fifth the weight of steel.

Proven-In-Use Applications: Presently being used for countless mechanical, electrical and chemical applications. Specifically—gears, bearings, couplings, rods, tubes, sheets, terminal boards, control pulleys, variable resistors, insulation, printed circuitry and other fabricated parts.

Bonus Advantage: The Richardson Company offers you a complete and integrated plastics service from research and design through fabricated products of all sizes and shapes.

Availability: INSUROK is available in a wide variety of grades, sizes, thicknesses in sheets, rods and tubes and fabricated parts. New grades are constantly being developed for new or improved products.

If you have a challenging product application, rely on the man from Richardson to help solve your problem. Write or phone for further information and catalogs today.

INSUROK® is a registered trademark of The Richardson Company.

THE RICHARDSON COMPANY

FOUNDED IN 1858

2703 LAKE STREET, MELROSE PARK, ILLINOIS
Sales offices in principal cities

Laminated Fabricated and Molded Plastics

For more information, turn to Reader Service card, circle No. 435

strip and sheet. Thicknesses range from, 0.074 to 0.091 in. for 50-in. widths 0.0972 to 0.127 in. for 60-in. widths, and 0.127 to 0.375 in. for 72-in. widths. KEY NO. 626

Bright Cadmium Plate

Hanson-Van Winkle-Munning Co., Church St., Matawan, N. J. has introduced a new brightener for cadmium plating called Cadalume L. The producer says the brightener can be added directly to a cadmium plating bath without any break-in period.

The brightener is said to have the following advantages:

1. Increased plating speed.
2. Improved deposit distribution and throwing power.
3. Heavier deposits without loss of brilliance or tendency to form nodules.
4. No tendency to induce pitted deposits. KEY NO. 627

Titanium Carbide Has Good Wear Resistance

A new cemented titanium carbide called VR-65 is said to greatly increase tool life in numerous machining applications. For example, when VR-65 was used to machine steel forgings, tool life was increased from 15 pieces per cutting edge with conventional carbides to 90 pieces with VR-65.

The material, developed by Vascoloy-Ramet Corp., 800 Market St., Waukegan, Ill., is a cemented titanium carbide alloyed with other metal carbides (compositions not revealed). It is fabricated by conventional powder metallurgy techniques.

The new carbide has a Rockwell hardness of A92 and a rupture strength of 175,000 psi. It has a fine grain structure and is free from porosity. It can be brazed to steel shanks, and can be ground by conventional carbide grinding methods.

According to the developer, the high titanium carbide content in the material imparts excellent crater resistance and freedom from build-up when machining steel. The high

Find the "other man"!

Find the "other man" and you'll find another reason why you should come to Carlson for your stainless steel plate and other stainless products. The "other man" is an unseen crane operator. He, together with the hook-up man directing the loading of a stainless head in our shipping bay, is working "after hours" for one purpose—to assemble and ship a customer's order *fast*.

Why? The customer's production schedule may have changed suddenly. Perhaps quick delivery is needed to repair a vital piece of equipment. Whatever the reason, the customer knows he can count on Carlson for exceptional service. For Carlson is accustomed to producing and delivering, *fast*, a wide variety of high quality stainless steel products.

Specialized Carlson service is as near to you as your phone. Call or write for prompt action. The phone number: DUdley 4-2800.

G.O.CARLSON *Inc.*

Producers of Stainless Steel

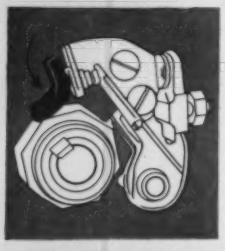
126 Marshallton Road
THORNDALE, PENNSYLVANIA
District Sales Offices in Principal Cities

PLATES • PLATE PRODUCTS • HEADS • RINGS • CIRCLES • FLANGES • FORGINGS • BARS AND SHEETS (No. 1 Finish)

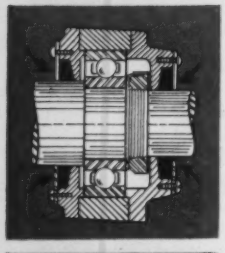
For more information, turn to Reader Service card, circle No. 326

How
FELT
BY FELTERS
Can Improve Product
SEALING and LUBRICATION

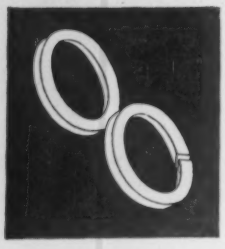
DuFelt is a laminated combination of Felters' felt and Hycar; and is recommended for sealing of lighter oils when no head exists. Seals and lubricates at the same time; and offers improvements over other materials.



Felt is an ideal wicking and lubricating material which can be designed into special assemblies like this distributor cam shown here. Lubrication is constant, wear reduced, and felt can be shaped to cover all required areas.



Lifetime bearing lubrication is now possible by selection of correct SAE grade, and designing into sealed bearing. Felt filters out contamination and works as combined reservoir and wick, directing oil flow to required areas.



Mechanical felt seals permit a close seal without undue pressure. Felt can be waterproofed and provides superior grease and oil retaining and dust, dirt and grit exclusion.

To help you get the most out of FELT, send for the Felters' Design Book. Write, today.

Ask for **FELT** *from . . .*
The **FELTERS** Co.
220 SOUTH STREET
BOSTON 11, MASSACHUSETTS
Pioneer Producers of Felt and Synthetic Non-Woven Fabrics

PE 9-58

For more information, turn to Reader Service card, circle No. 469

What's new IN MATERIALS

hardness and fine grain structure are said to provide good resistance to edge wear.

The carbide is available in the form of throw-away inserts at prices 20% above the base price of standard carbide grades. KEY NO. 628

Coated Glass Stops Static Electricity

Borosilicate glass panels coated on one side with a thin, transparent metallic film are available from Corning Glass Works, Corning, N. Y. for shielding against static electricity. The coating on the glass intercepts static electricity, which then can be grounded by such devices as conductive tape or carbon buttons.

Panel transmits light

The electrically conductive coating is permanently fired on the surface of the glass and will not abrade. The coated panel is said to transmit 70% of visible light.

According to Corning, the glass resists thermal shock and corrosion, and is easily maintained and cleaned.

The panels, available in sizes up to 2 by 6 ft, are expected to be used in computers to carry off the static electricity that builds up in the equipment. The clear glass will permit visual checking of the equipment.

Corning says the panels could also be used in laboratories, hospitals, and radio and television studios.

KEY NO. 629

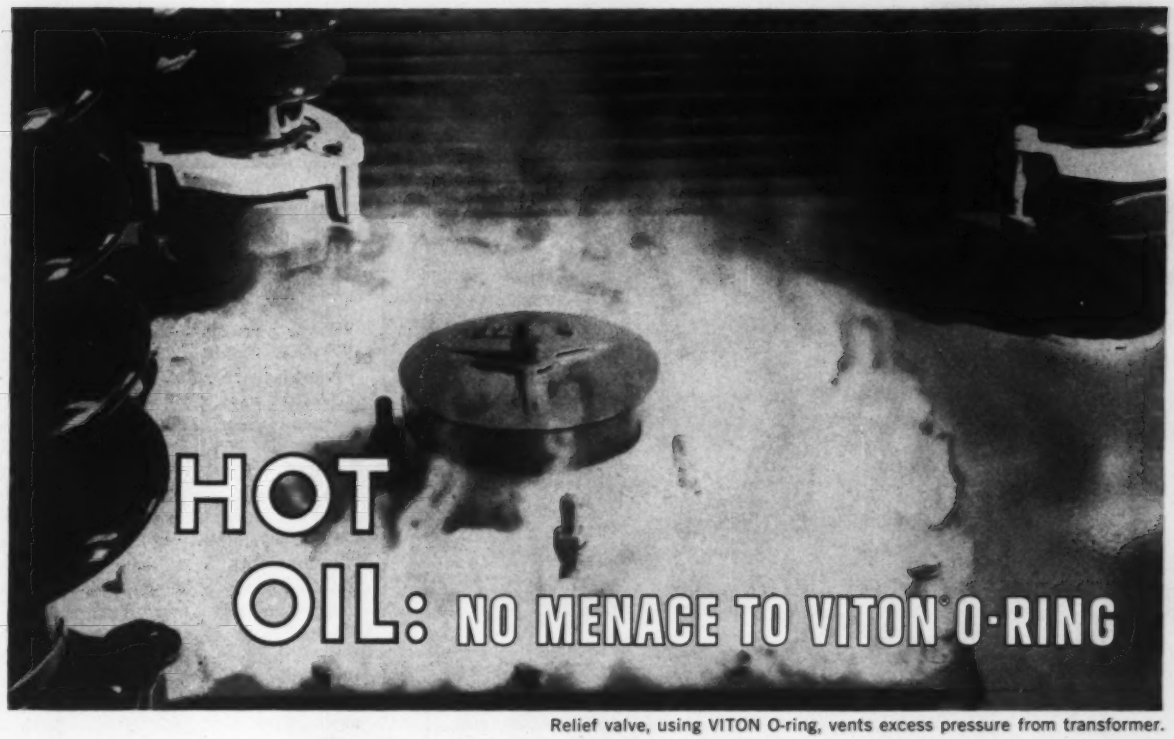
Stretchable Paper Has High Strength

A new stretchable kraft paper joins two other stretchable papers introduced in recent years—X-Crepe (M/DE, Nov '57, p 138) and Clupak (M/DE, Aug '58, p 110).

The new paper, called Expanda-Kraft, was developed by Hollingsworth & Whitney Div., Scott Paper Co., Chester, Pa.

Paper withstands repeated impact

A big feature of the paper is its high strength. A demonstration showed that four plies of the paper



Relief valve, using VITON O-ring, vents excess pressure from transformer.

The ideal pressure-sensitive relief valve for sealed, oil-filled transformers should be "selective." It should withstand normal pressure changes, yet respond quickly to emergencies.

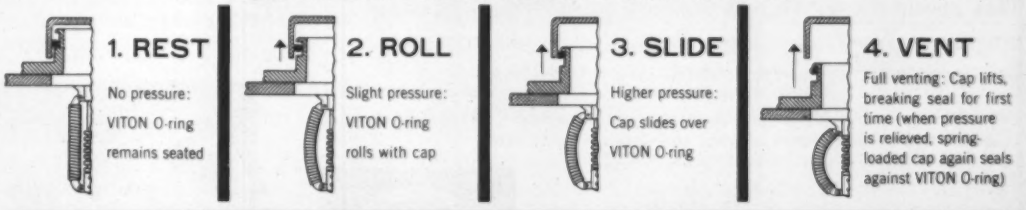
General Electric's Medium Transformer Department at Rome, Georgia, designed a mechanical relief valve that would not only solve this problem of selectivity, but would actually reset itself after discharge. The valve's success depended on an O-ring able to maintain a tight seal in spite of repeated exposure to hot insulating oil. With an O-ring made from VITON synthetic rubber, this novel spring-loaded relief valve has proved itself both faster and more reliable than previous devices*.

OTHER APPLICATIONS OF VITON

VITON'S outstanding resistance to heat, oil, fuels, solvents and chemicals has improved the performance of a wide range of industrial equipment. O-rings, packings and seals have been molded from VITON . . . tanks have been lined, fabrics have been coated and wire has been jacketed . . . all with VITON. If *you* have a problem involving high temperatures and corrosive fluids, VITON will serve where other elastomers fail. See your rubber goods supplier for information, or write for our booklet of specific data, with current and suggested applications. E. I. du Pont de Nemours & Co. (Inc.), Elastomer Chemicals Department MM6, Wilmington 98, Del.

**Case history from the* ELASTOMERS NOTEBOOK—*subscription free on request.*

HOW RELIEF VALVE USES VITON O-RING

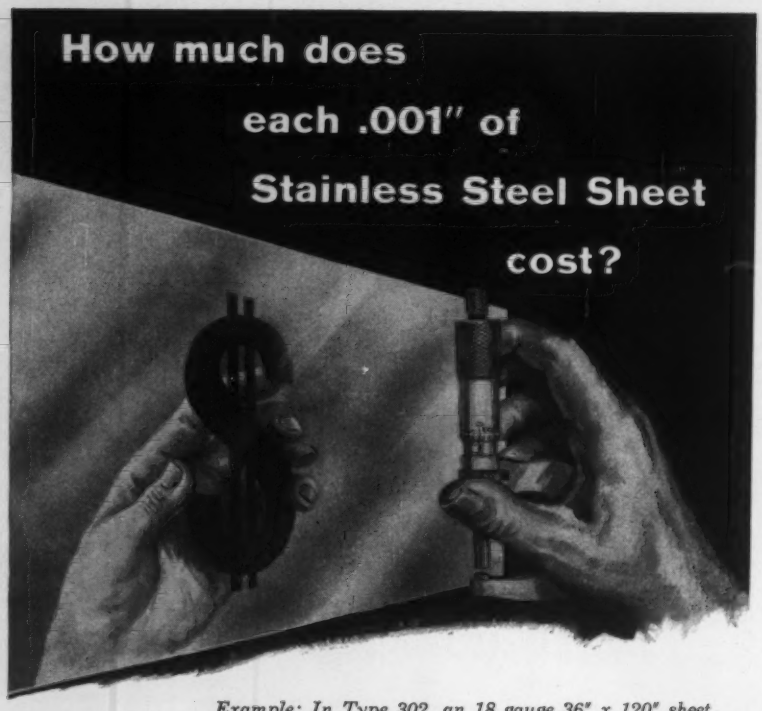

1. REST
No pressure: VITON O-ring remains seated
2. ROLL
Slight pressure: VITON O-ring rolls with cap
3. SLIDE
Higher pressure: Cap slides over VITON O-ring
4. VENT
Full venting: Cap lifts, breaking seal for first time (when pressure is relieved, spring-loaded cap again seals against VITON O-ring)

DU PONT
REG. U. S. PAT. OFF.

SYNTHETIC RUBBER
NEOPRENE HYPALON® VITON® ADIPRENE®

BETTER THINGS FOR BETTER LIVING . . . *THROUGH CHEMISTRY*

For more information, turn to Reader Service card, circle No. 423



Example: In Type 302, an 18 gauge 36" x 120" sheet has a base price of 52¢ per pound. In sheets of this size, each .001" of thickness weighs 1.26 pounds per sheet. Thus, each .001" of unnecessary thickness costs you at least 65.5¢ more per sheet.

On the surface this may seem insignificant, but it has a marked effect on the total price you pay for a given quantity of stainless steel sheet. With cost a factor, this can be important since stainless steel is purchased by weight.

Using the above example, a mere .001" of unnecessary thickness costs you $20.76 more per ton. If you figure the maximum allowable gauge thickness variation of plus or minus (10%), you can readily see that the price you pay for overall sheet thickness could involve much needless cost.

Washington Steel has the equipment and the experience to produce MICROROLD stainless steel to tolerances much closer than standard industry tolerances. Usually money can be saved by first selecting the minimum gauge that will serve the requirements of the application, and then specifying that the thickness be rolled to the light side of the gauge range. This specification involves no cost extra and is standard practice at Washington Steel. (If exact close tolerances must be guaranteed, there is a nominal additional charge.)

Consult your nearest MicroRold Stainless Steel Distributor. He will gladly show you how to save money on your stainless steel purchases.

Washington Steel Corporation
6-F Woodland & Griffith Avenues
Washington, Pa.

WASHINGTON STEEL CORPORATION MicroRold STAINLESS SHEET & STRIP

For more information, turn to Reader Service card, circle No. 421

withstood repeated impact from a football tossed at high speed from a distance of 50 ft. Four plies of ordinary kraft paper broke with a single pass from the same distance.

P. C. Baldwin, vice president of manufacturing and engineering, says Scott's new "roll crepe" process (details not revealed) imparts as much as 30% extensibility to kraft paper. However, research showed that paper with too much stretch did not have other properties essential for efficient packaging applications. As a result, he says Expanda-Kraft is being produced with approximately one and one-half times more cross-direction and five times more machine-direction stretch than ordinary kraft paper. This permits the paper to give without breaking, and makes it puncture resistant under strain or impact.

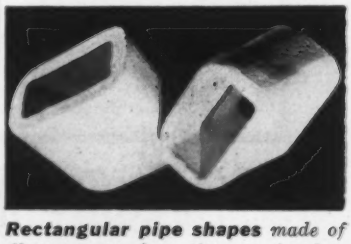
The principal use of the paper at present is multiwall bags. However, it is expected to be used for shopping bags, magazine and catalog wrappers, and similar packaging applications. KEY NO. 630

Potassium Titanate Sold as Blankets, Disks

Fibrous potassium titanate, introduced last year by Du Pont (see M/DE, Jan '59, p 117), is now available in the form of thermal insulating blankets, disks, bowls and rectangular and circular pipe shapes from Resisto Chemical Inc., Wilmington, Del.

The specially formed shapes are called Resistotherm. They have an average density of 16 lb per cu ft. The blankets measure ¼ to 2 in. in thickness by 22 in. square.

The low thermal conductivity of



***Rectangular pipe shapes** made of fibrous potassium titanate insulate well at temperatures up to 2200 F.*

BEE

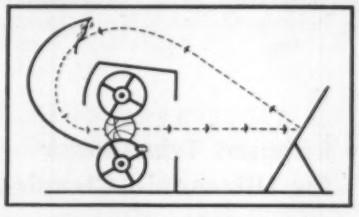
FINISHES • COATINGS • PLASTISOLS

Briefs on Sports Equipment Coatings... Selecting Reflective Mirror-Bright Finishes...

Coatings for Basketballs

W. J. Voit Rubber Corporation, Los Angeles, recently introduced the Voit Icosahedron Ball, made by a new ball building method that continuously spins nylon filaments on a ball bladder in the predetermined pattern of a perfectly symmetrical polyhedron. This, says Voit, is the strongest, best balanced carcass pattern ever applied to a ball. Another unique feature of the ball is the coating on the vinyl cover: BEE's XR-373. Based on a BEE automotive finish, XR-373 is a special spraying formulation developed for Voit to give the ball just the right handling "feel," "slip," and drag.

To test the improved strength and design of the ball—and the coating—Voit regularly puts production samples through a specially-constructed torture machine that methodically attempts to bounce the living daylights out of the ball—and the coating.



Bounce Machine squeezes the ball through rollers and slams it against backboard over and over.

After 30,000+ bounces in 24 hours (the equivalent of 5 months' use), XR-373, and the ball, come out smiling, secure in the knowledge that similar balls coated with XR-373 have successfully passed 100,000 cycles. XR-373 also undergoes lacquer lift tests to make certain the coating withstands possible migration of the vinyl in the cover.

The moral here is clear. This is another example of how BEE Coatings Go Everywhere, do the job under various stresses and strains—on plastics as well as on metals. BEE's Coatings Selector might help you find just the right coating for the job at hand or indicate how we can develop a special coating to meet your needs. Fill in the pertinent information on the coupon to get your copy.

How Do You Select Reflective Coatings?

Formerly largely restricted to reflective, decorative finishes on plastic novelty items, vacuum metallizing is now embracing ever-widening use on automotive hardware and appliance panels and components—on die cast aluminum and zinc components as well as on plastics.

The introduction of improved lacquers for base and top coats used in vacuum metallizing has helped considerably in broadening the range of applications. BEE CHEMICAL COMPANY produces a host of coating systems, each one perfected to give you the required functional properties as well as desired decorative effects. More durable, faster curing systems—systems for exceptional alcohol resistance or for an exceptionally high degree of brilliance are now available from BEE.

BEE supplies these coatings to metallizers as base coats, top coats and back up coats which are applied by means of spraying, flow coating or dipping. The base coat is applied to the surface before metallizing and serves to level the surface, also acts as the adhesive link between the plating and the part. The clear top coat serves primarily to protect the metallic film after plating. Frequently, transparent colorants are added to this coating, though color may also be achieved by means of dip dyeing. An opaque back up coat serves to protect the metallic film on the second surface of clear plastic parts.

The selection of coating systems is a matter of skill and experience in knowing what combinations of coatings will result in the physical properties and appearance qualities desired for the parts.

This, however, is not a deterrent to getting top quality vacuum metallizing of your parts. BEE CHEMICAL COMPANY works closely with vacuum metallizers throughout the country perfecting systems for all types of applications. We also help manufacturers who do not have these facilities to find a dependable, conveniently-located metallizer who can furnish the quality work they are seeking. The result is a three-way collaboration that results in a very profitable association for all concerned.

The attached coupon will bring our COATINGS SELECTOR to you, listing metallizing systems available from BEE. By checking the appropriate item we will also recommend a dependable vacuum metallizer in your area for your specific application.

Plastisols Replace Rubber in Water Sports Equipment

Laminated Products Co., San Angelo, Texas, chalks up another successful application for plastisols in their use as binders on Lam-Pro Water Skis.

More and more manufacturers are discovering the more attractive sales appeal of plastisol binders: white binders are white, and with plastisols a complete range of colors is possible (not so with rubber binders). Plastisols give the binders improved water resistance, making them more durable. Resistance against ozone attack is markedly superior to rubber binders, too.

Add to these advantages the *lower material cost* and manufacturing in inexpensive open casting molds and you have an air-tight, water-tight case for plastisols. This points the way to many other instances where rubber parts are currently being used in water sports and other equipment.

Manufacturers that have turned to Logosols (BEE's trade name for plastisols) have one other important bonus. Logosols are custom-formulated to do a specific job, to give your product the ultimate in desired physical properties as well as to furnish you with an improved, problem-minimized production material. BEE's Technical Service Group works with you to keep it that way. Call on them via the coupon below and get the Logosol story.

Tear off and clip to your letterhead

☐ Please send me COATINGS SELECTOR. Interest is in
☐ Vacuum Metallizing ☐ General Coatings ☐ Plastisols
☐ Interested in Vacuum Metallizing but am not a plater.
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INDIUM — a high performance bearing metal — increases strength and hardness of bearing. It improves significantly resistance to corrosion by acid from lubricating oils and permits bearing surface to retain oil film better. Where high oil temperatures are encountered, it exhibits longer bearing life.

The high anti-seizure properties of lead-indium bearings make them ideal for heavy or high speed service where dependability and long life are essential. These bearings are now used in most European cars and in many aircraft and diesel engines in both Europe and North America.

INDIUM — a constituent for low melting-point alloys — Wood's metal plus 19% Indium melts at 117°F. Such alloys can be used for foundry patterns, fusible safety links and plugs and many other applications.

INDIUM — a solder material — Indium wets most metals and non-metals making it and many of its alloys a specialized solder for many applications, including glass-to-glass or glass-to-metal seals.

Cominco produces TADANAC Brand INDIUM in a variety of shapes including ingots, plates, wire and ribbon. Standard Grade Indium is 99.97% pure. Can its special qualities be of use to you? Inquiries are invited regarding the application of this versatile metal to your needs. Send for our brochure TADANAC Brand INDIUM.

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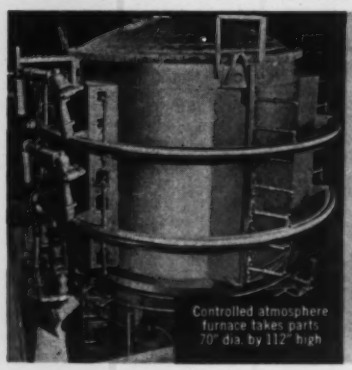
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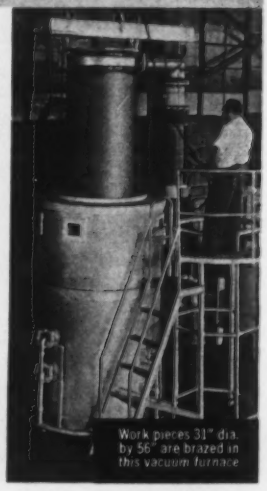
Work pieces 31" dia. by 56" are brazed in this vacuum furnace

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Wall Colmonoy furnace plants are maintained in Michigan, Pennsylvania, Ohio, and California

For more information, turn to Reader Service card, circle No. 365

the insulating material is due in large part to the high refractive index of the fibers, and to their dimensions. KEY NO. 631

Fluorosilicone Sponge Resists Fuels, Oils

A fluorosilicone sponge rubber compound is said to have excellent resistance to fuels and lubricants at high temperatures, and good resistance to ozone, aging and weathering. It is also said to have good dielectric properties and good resistance to compression set.

Called Cohrlastic 10530, the material is supplied as molded sheets by Connecticut Hard Rubber Co., 407 East St., New Haven 9, Conn. Sheet sizes are 12 by 12 in. and 24 by 24 in., in thicknesses of 1/8, 3/16 and 1/4 in. The sheet has a closed cell structure.

A ⅛-in. thick sheet of the material sells for $14 per sq ft.

The new material is suitable for soft gasketing, vibration dampening, fairing strips, pads and cushions. It is especially suitable in applications where there is an extreme low or high temperature with simultaneous exposure to fuels and oils.

KEY NO. 632

Efficient Transducer for Ultrasonic Cleaning

A new, highly efficient ultrasonic cleaning system has been introduced by Branson Ultrasonic Corp., 40 Brown House Rd., Stamford, Conn. Heart of the new system is a sandwich-type lead zirconate titanate transducer that is said to have twice the cleaning efficiency of conventional barium titanate transducers.

Other advantages of the new

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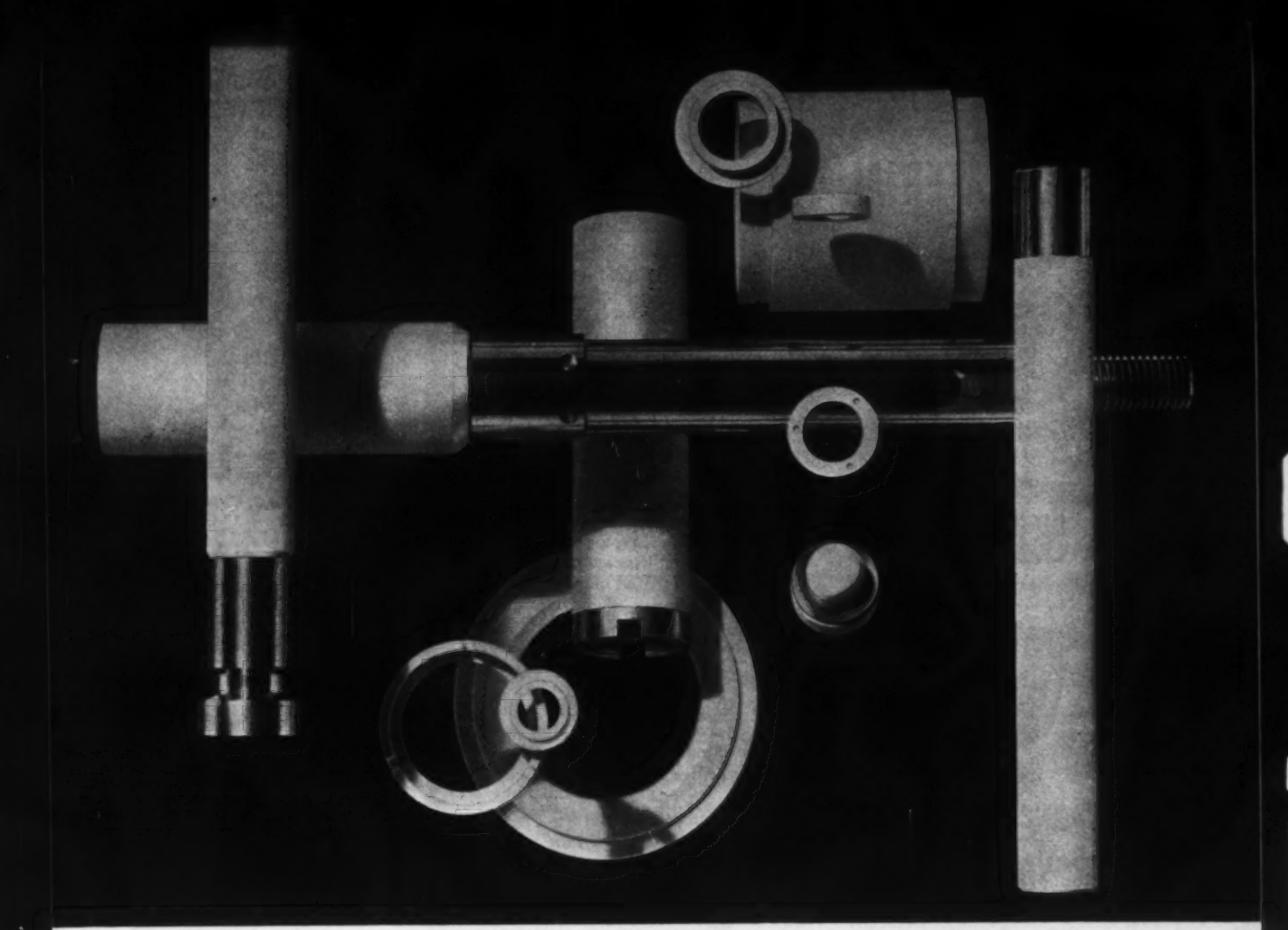

Coors Alumina Ceramics Replace Expensive Metals for Vital Pump Parts

Why? Because it is a "superb material for corrosive or abrasive conditions," according to a leading builder of large oil field pumps.

These destructive twins — corrosion and abrasion — have led pump designers to use Coors High Strength Alumina Ceramics for the vital parts of pumps, such as plungers, cylinder liners, seal faces in mechanical shaft seals, shaft protection sleeves, and ball check valves. Consequently, today you'll find Coors Ceramics in big reciprocating pumps used for oil field and industrial plant service as well as in small centrifugal pumps used in domestic hot water heating systems and washing machines.

In addition to Coors Ceramics ability to withstand corrosion and abrasion, they also have excellent strength characteristics — plus dimensional stability. They do not warp or change shape. That's one reason they are used for seal faces in shaft seals... when you lap these materials flat, they stay flat!

Perhaps your abrasive and corrosive problems can be solved economically with Coors Ceramics. We shall be glad to help you — just write us at Golden or contact one of our regional sales managers.

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East Coast.....John J. McManus
MA 7-3996–Manhasset, N.Y.

New England.....Warren G. McDonald
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Southwest.....Kenneth R. Lundy
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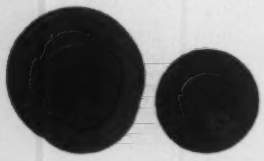
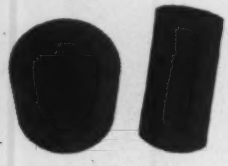


• Molds for powder metallurgy?

• Sintering boats?



• Crucibles, jigs, plates?

• Similar hot applications?

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Speer carbon and graphite parts are not wetted by molten metals. They hold their shape with no warping, regardless of temperature. They have high heat transfer and will not break down under severe thermal shocks...will not crack or split... are chemically inert.

Easily machined or fabricated, Speer carbon and graphite parts can be provided in almost any size and shape to your *exact* dimensional tolerances. If you have a design problem involving high temperatures, examine the advantages—and economies of Speer Carbon. Speer's knowledge and experience is yours for the asking—mail the coupon today for further details.

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What's new IN MATERIALS

transducer are:

1. It can be operated at temperatures up to 200 F, compared to 160 F for conventional barium titanate transducer are:

2. It can accept higher electrical input power.

3. It has flat tuning characteristics which reduce the need for close frequency control of the generator.

4. It can be reclaimed by transferring from a worn to a new housing. The cost of repairing a conventional barium titanate transducer almost equals the cost of a new unit, says Branson. With the new transducer, however, cost of replacing the stainless steel housing is only about 20% of the initial transducer investment.

The cleaning system, called Sonogen Z, is available in both high and medium intensity versions. Standard tank capacities range from 2 to 75 gal.

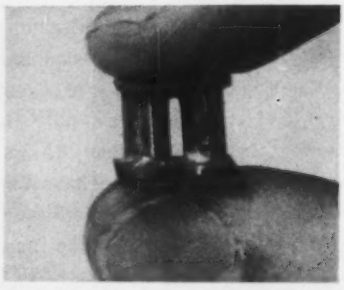
Potential applications

The unit is recommended for cleaning automotive and aircraft parts, optical equipment, intricate mechanisms, glassware, silverware, jewelry and surgical instruments. It is also recommended for removing paints, adhesives, labels and accumulated soils from various products.

KEY NO. 633

Telluride Alloy for Thermoelectric Cooling

A new bismuth telluride alloy is said to make thermoelectricity the most efficient as well as the most economical means of cooling volumes



***Thermoelectric module** made from a bismuth telluride alloy reaches low temperatures within seconds after electric current has been applied.*

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Recent tests of Mesa Diall molded parts in different chemicals show unusually high resistance to chemical disintegration. In the field, a Mesa Diall compound shows indefinite resistance to 45% solution potassium hydroxide... other plastic materials actually fell apart within 2 months on exposure to this solution.

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Hypersonic flights of tomorrow will depend on lightweight, high-strength materials for high-temperature applications. To meet these requirements, engine builders are turning to Wah Chang Corporation, the world's largest producers of high-purity columbium and columbium base alloys... made by vacuum electron beam and vacuum arc melt processes.

WCC casts columbium ingots up to 17" in diameter and weighing as much as 3000 lbs. From these ingots WCC fabricates under the strictest quality control bar, rod, sheet and tubing to meet customers' specifications.

Design engineers depend on the combined metallurgical skills and product reliability of WCC... leading producers of high-temperature metals for over 41 years. Major suppliers to engine, airframe and missile manufacturers, Wah Chang Corporation also produces and fabricates *Hafnium, Zirconium, Tantalum, Tungsten, Molybdenum* ... employing the most rigid quality controls from raw material to finished product.

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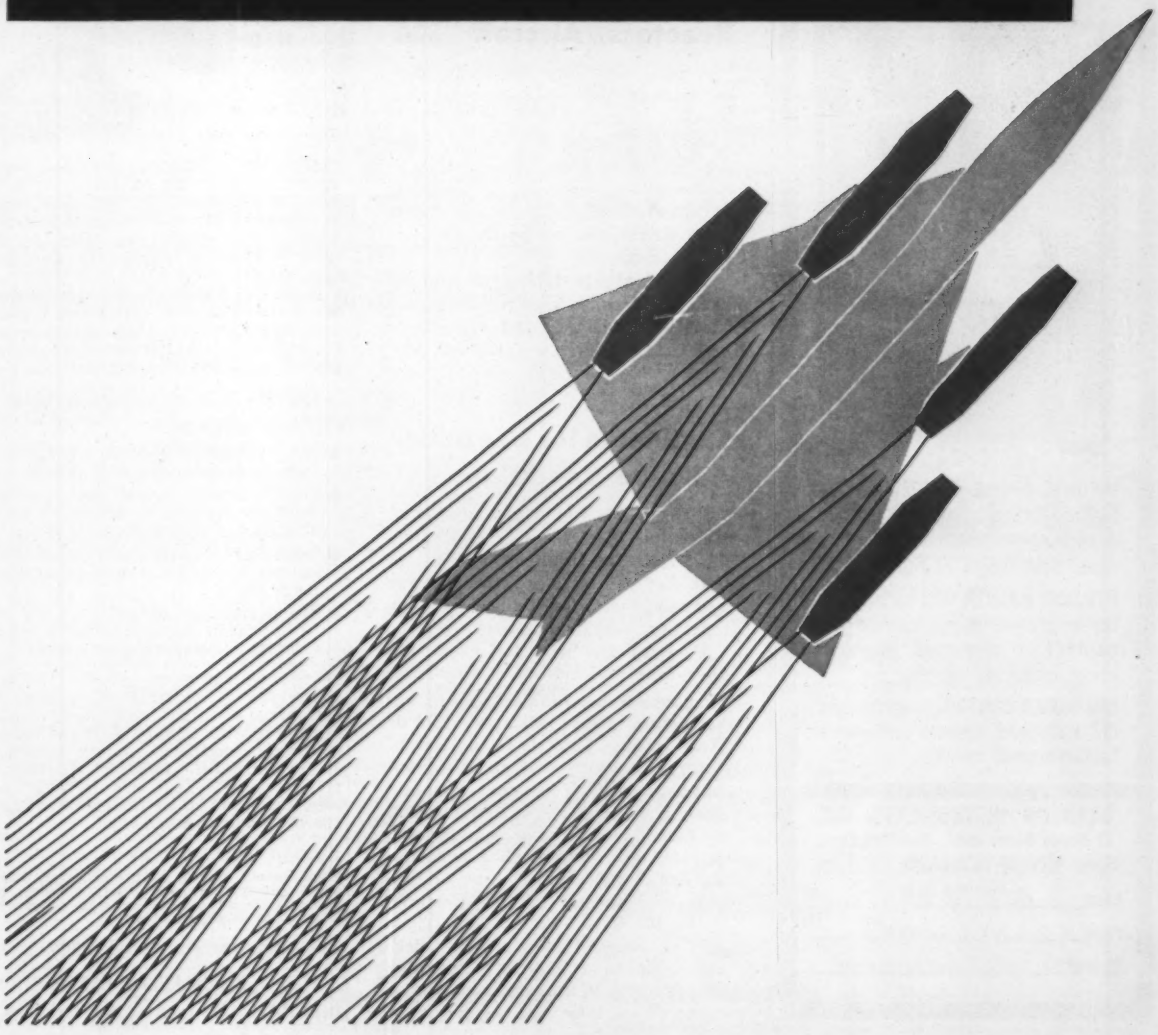
BRINGING TOMORROW CLOSER WITH NEW METALS

built-in thermal safety at mach 2 and beyond



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the new Branson pulse-echo SONORAY®

Flaw Detector for contact or immersed testing makes a dramatic improvement in the acoustical "picture" of internal structure.

SENSITIVITY reveals 1/64" FBH full-scale at 2.25 and 5.0 mc/s;

RESOLUTION clearly defines 3/64" FBH at 3/16" at 2.25 mc/s in contact testing;

CALIBRATED CONTROLS make it possible to return precisely to previous conditions;

INFINITE CHOICE OF FREQUENCIES without tuning: broad-band receiver adapts automatically to any transducer from 0.4 to 10.0 mc/s;

PYRAMID MARKER with variable delay for precise interpretations with contact or immersed, angle or compression techniques.

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What's new IN MATERIALS

up to 4 cu ft.

S. Shapiro, president of Materials Electronics Products Corp., 990 Spruce St., Trenton, N. J., says the bismuth telluride alloy is approximately 60% more efficient than a mechanical compressor for cooling purposes.

The company makes the *n* and *p* type alloy in crystals up to 18 in. long. Both crystals and thermoelectric modules made from the crystals are available for experimental or production purposes. KEY NO. 634

Beryllium Tubing for Reactors, Aircraft

A pure beryllium tubing for use in nuclear reactors, aircraft and missiles is available from Superior Tube Co., Norristown, Pa. in sizes from 0.250 to 2 in. o.d.

The tubing, produced in England by Chesterfield Tube Co., is made from sintered billets by the hot extrusion method.

The beryllium tubing is said to have low density, high rigidity, good oxidation resistance and high thermal conductivity. KEY NO. 635

Laminates for Use under Adverse Conditions

Six plastics laminates have been placed on the market recently. A big feature of the new materials is that they can be used under adverse operating conditions such as high humidity, heat and impact.

Four of the new laminates are glass-base and two are paper-base.

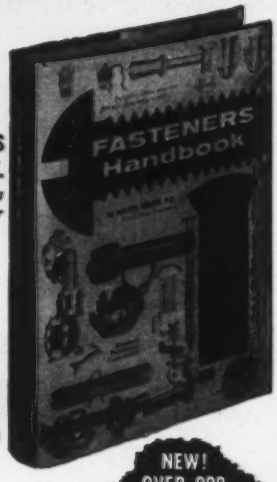
1. Glass-base laminates

Polyester-glass: Micarta Div. of Westinghouse Electric Corp., Hampton, S. C. recently introduced a glass mat-reinforced polyester laminate that is said to resist deterioration by flame, moisture, arcing, leakage currents and impact. The new material is also said to retain its physical properties at temperatures up to 265 F.

It is supplied as plate in thicknesses up to 2 in., as rectangular shapes up to 36 in. square, as angles up to 60 in. long, and as sheets 36

Details, ideas, sources for all fastening needs . . .

FASTENERS Handbook



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Consulting Engineer

1957
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FASTENERS HANDBOOK greatly facilitates the review of available information, the making of a valid selection, and contacting the sources of supply. It can be used by design engineers, patent attorneys, sales personnel, fastener distributors and jobbers—in fact, anyone who needs solid information on fasteners available for mechanical assembly.

Everything in fasteners

Rivets, Inserts, Screws, Bolts, Studs, Nuts, Washers, Retaining Rings, Pins, Nails, Metal Stitching, Quick Release Fasteners, Masonry Anchoring Devices, Hose Clamps, Manufacturers Directory.

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White Metal multiple hole hollow complex features inner 3/32" strut for direct stress transfer between 5/16" top and 9/32" bottom walls. Extruded of Alloy AZ31B.

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One of the World's Largest Producers of Magnesium Alloy Mill & Finished Products

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ADD BEAUTY, COLOR, SALES APPEAL

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Every day product designers, industrial finish and material engineers are finding new, profitable uses for Cellusuede Flock — industry's most versatile product coating. With these cotton, rayon or acetate fibers, you can add new beauty, color, and sales appeal to your product, provide a durable protective finish, silence noises, or dampen vibration. Best of all, the soft velvet-like Cellusuede finish is easy to apply to wood, metal, plastic, fabrics, leather, cardboard, or paper surfaces, either on a modified or production line basis. It's inexpensive, more durable than fabric, and readily available in a wide range of textures and beautiful colors. Investigate today the profit possibility of using Cellusuede for your product.

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Edited by
RALPH H. SONNEBORN
Technical Service Dept.,
Plastics Reinforcement Division,
Owens-Corning Fiberglas Corporation

1954, 250 pages, $4.50

This valuable book offers the first *complete* treatment ever published on the subject of reinforced plastics, the amazing post-war structural material that has found its way into scores of new industries and products.

Written for both design engineers and executives in the materials industries, the book covers in full detail the resins and glass reinforcements used in reinforced plastics, molding techniques, inspection and testing, properties, and design considerations.

This important book will provide all those concerned with reinforced plastics—molders, materials suppliers, government agencies, engineers—with a wealth of information never before available in a single volume.

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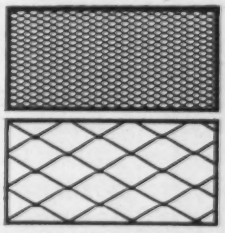
SOMETHING NEW IN EXPANDED METAL



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- **fine mesh sizes to close tolerances**
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Somers

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What's new IN MATERIALS

PROPERTIES OF NO. 6098 LAMICOID

MECHANICAL PROPERTIES	
Ten Str (lengthwise), psi	26,000
Flex Str (lengthwise), psi	16,000
Impact Str (Izod), ft-lb/in.	13.0
ELECTRICAL PROPERTIES	
Dielectric Str (par., step by step), kv	45
Dielectric Constant (1 mc)	2.68
Arc Resistance, sec	185

in. wide. **KEY NO. 636**

TFE-glass: A TFE-glass laminate that is said to have good resistance to chemical attack, excellent electrical properties, good resistance to mechanical abuse, and low cold flow under heat and pressure has been announced by Mica Insulator, Div. of Minnesota Mining & Mfg. Co., Schenectady, N. Y.

The laminate, called No. 6098 Lamicoid, is said to be ideal for high temperature (390 F) printed circuits and for microwave applications.

Price of the new laminate ranges from about $25.60 per sheet (0.006 in. thick) to $241 per sheet (¼ in. thick). **KEY NO. 637**

Melamine-glass: A melamine-impregnated glass cloth laminate has been developed by Continental-Diamond Fibre Corp., Newark, Del. A big feature of the laminate is its low water absorption. It is also said to have improved machining properties. **KEY NO. 638**

Epoxy-glass: A copper-clad glass-reinforced epoxy laminate has been developed by General Electric Co.'s Laminated Products Dept., Schenectady, N. Y.

The producer says the laminate, called Textolite 11585, is ideal for use where printed circuits must be forced into the laminate to produce a flush surface.

The new laminate is said to have high insulation resistance, low water absorption, high stability in humidity, and good bond strength.

It is supplied in sheets measuring 36 by 48 in., 36 by 36 in. and 36 by 72 in. **KEY NO. 639**

2. Paper-base laminates

Phenolic-paper: A copper-clad, phenolic - impregnated, paper - base laminate has been introduced by Taylor Fibre Co., Norristown, Pa. The new material, called Fireban 321, meets tentative Underwriters Laboratory requirements for flame

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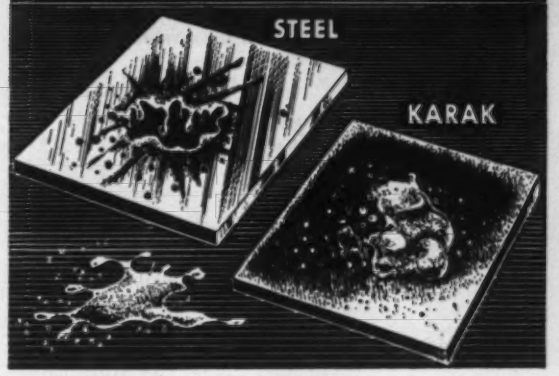

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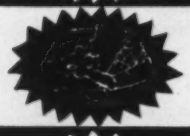

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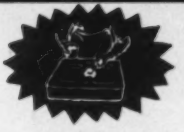

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retardance. It is also said to have high insulation resistance and excellent punching characteristics.

The copper foil, furnished on one or both sides in either rolled or electrolytically deposited form, has a minimum purity of 99.5%.

The laminate is supplied in sheets approximately 36 by 48 in., in thicknesses from 0.020 to ¼ in.

KEY NO. 641

Phenolic-paper: Another paper-base phenolic laminate is said to combine flame retardance with excellent cold punching characteristics at slightly more than half the cost of epoxy-paper laminates. For laminates 1/16-in. thick with 1 oz copper on one side, the new phenolic-paper laminate costs 96¢ per sq ft, compared to $1.55 per sq ft for an epoxy-paper grade.

The producer, National Vulcanized Fibre Co., Wilmington, Del., says that up to now it was necessary to use epoxy-paper laminates in order to combine flame retardance with good cold punching characteristics.

The new laminate, called Phenolite Grade XXXPC-476, is supplied in two sheet sizes, 39 by 39 in. and 39 by 47 in., in thicknesses from 1/32 to ¼ in. **KEY NO. 642**

Other News . . .

Metals

▸ Color-coated steel in nine new colors is available from Stran Steel Corp., Div. of National Steel Corp., Detroit 29. The new line of colors will be available on 26-gage panels, 36 in. wide in any length.

KEY NO. 649

▸ A new wedge wire screen known as Rima and made of wire with thinner profiles than previously available has been introduced by Cross Perforated Metals Co., Div. of National-Standard Co., Carbondale, Pa. The screens are made of stainless and carbon steels. They are designed for screening, sifting, dewatering, washing and filtering applications. **KEY NO. 650**

Plastics

▸ Two improved, non-irritant epoxy laminating resins are available from Marblette Corp., 37-31 30th St., Long Island City 1, N. Y. Maraset

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What's new IN MATERIALS

No. 607-AA is said to have excellent wetting characteristics so that it can be combined with glass fibers for molding into tools and other reinforced plastics parts. Maraset No. 606 is suitable as a surface coating for molds or models where glass fiber patterns or textures should not show through. **KEY NO. 651**

▸ Armour Alliance Industries, Div. of Armour & Co., 16123 Armour St. N.E., Alliance, Ohio is adding flexible urethane foam to its line of cushioning and packaging materials. The foam has a density of 1.8 lb per cu ft. **KEY NO. 652**

Rubber

▸ Fluorocarbon rubber parts with excellent resistance to fuming nitric acid and other corrosive media are available from Vernay Laboratories Inc., Yellow Springs, Ohio. The parts, compounded with a special peroxide cure, are said to withstand temperatures up to 400 F. **KEY NO. 653**

▸ Parker Seal Co., Div. of Parker-Hannifin Corp., 10567 W. Jefferson Blvd., Culver City, Calif. has developed a Viton o-ring compound that is said to retain its flexibility at temperatures below —100 F. The compound is called V500-6. **KEY NO. 654**

Other nonmetallics

▸ A lightweight ceramic foam block has been introduced by Emerson & Cuming, Inc., 869 Washington St., Canton, Mass. for use in very high frequency applications. The new material, called Eccosorb WG, can be used up to 1000 F. Each block has holes drilled through it so that a large surface area is available for heat dissipation. **KEY NO. 655**

▸ Audiofelt is the name of a new nonwoven felt designed for damping sound in speaker enclosures and phonographs. The material is available from Felters Co., 1803 Empire State Bldg., New York 1. **KEY NO. 656**

Finishes

▸ Ox-Off Lustre Dip is the name of a new solution for chemically polishing type 300 series stainless steels. Developed by Chemclean Products Corp., 15-08 121 St., New York 56, the solution is said to level off slight scratches and mars, and to leave a polished, smut-free surface. **KEY NO. 657**

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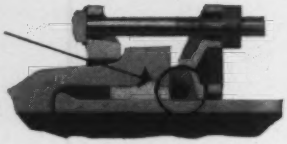

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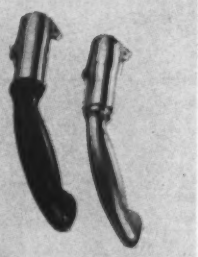

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continued from p 142

One-Coat Porcelain Enamels; New Developments Get Attention

The trend toward increasing use of one-coat porcelain enamels has been accelerated in recent months with the development of three new surface treatments and a new inexpensive sheet material.

The four developments were discussed at the 21st annual Shop Practice Forum of the Porcelain Enamel Institute, held in Columbus, Ohio last fall (see M/DE, May '60, p 204).

1. Three surface treatments

▸ J. C. Swartz of Westinghouse Electric Corp. and T. L. Stalter of Pemco Corp. described a special surface treatment for enameling iron and cold rolled steel that permits the application of one-coat porcelain enamels to refrigerator parts.

The two men say that 500 refrigerator parts have been successfully enameled by the process with no field complaints. Cost of enameling refrigerator pans was reduced 43% by the process, and cost of food compartments was reduced 30%.

The process, still under development, works as follows: 1) wash, 2) sandblast, 3) pickle, 4) nickel plate, 5) rinse, and 6) dry.

Cover coats applied directly to treated metal are fired at 1540 F for 3.4 min. The firing time is slightly longer than for conventional two-coat systems used on refrigerator parts.

Swartz and Stalter say that although smelted-in color coats work very well on the specially treated surface, not all cover coats will work satisfactorily.

▸ A one-coat, direct-on enameling process for cold rolled steel was described by E. D. Nobles of Ferro Corp. The method, now commercially available and described in the Oct '59 issue of this magazine (p 139), also utilizes special surface preparation.

Briefly, cold rolled steel is cleaned, rinsed, annealed, etched, nickel plated, rinsed and dried. Porcelain enamel is applied in the form of a thick, creamy slip. The slip is dried and fired at 1450-1550 F.

Nobles says one of the main requirements for good adhesion in a one-coat, direct-on process is the removal of 1.5 gm per sq ft of metal by sandblasting, acid solution or other means to insure good adhesion.

He says fishscale (holes in enamel surface) have been avoided in the process by using selected, cold rolled, rimmed steels. Low firing enamels are used on these steels to prevent any permanent deformation of metal during firing.

▸ The third one-coat porcelain enameling process described at the meeting is said to require a minimum amount of change in the present enamel shop set-up. The only change is the substitution of a citric acid pickle for the conventional sulfuric acid pickle.

The method is called the Ray-Davis direct-on process. It was described by S. C. Davis of Daco Corp. and J. J. McCallion of Charles Pfizer & Co., Inc.

The process consists of: alkali clean, hot water rinse, citric acid pickle, rinse, nickel sulfate bath, rinse, neutralizer, dry. A one-coat porcelain enamel is then applied to the treated surface and fired at temperatures from 1450 to 1550 F. The method can be used on cold rolled steel and enameling iron.

The citric acid pickle, which is the basis of the Ray-Davis process, removes from 2 to 4 gm per sq ft of iron from the surface of metal being treated. Enameling irons are etched more slowly than cold rolled steels.

2. Sheet material

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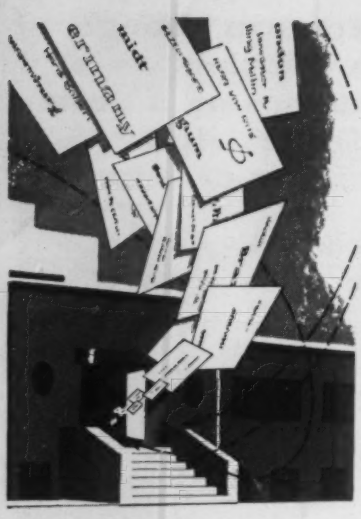

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2059

For more information, circle No. 456

described a special sheet steel material that is relatively inexpensive. He did not reveal its composition, but did say that the sheet ". . . is more competitive in cost than titanium-bearing steels developed for one-coat enameling systems."

The sheet material, called One-Cote, has undergone laboratory and limited plant trials. It is expected on the market shortly.

Gibbs says One-Cote enameling sheet has the same sag and drawing characteristics as enameling iron. One-coat enamels can be applied directly to the metal in conventional enameling equipment. Gibbs says one-coat enamels fired on the metal have good adhesion and good appearance with no fishscaling.

(For information on another new enameling iron for one-coat porcelain enamels, see M/DE, Mar '60, p 5.)

Vacuum Formed Mold Cuts Encapsulating Cost

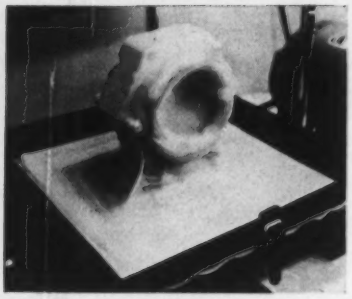
Want lower cost, more uniform encapsulated electronic parts? Then try vacuum-formed plastics molds, suggests M. Olyphant, Jr. of Minnesota Mining & Mfg. Co., 900 Bush Ave., St. Paul 6, Minn.

Olyphant recently described a novel approach for making plastics molds at the second annual National Conference on the Application of Electrical Insulation held in Washinton, D. C., Dec '59.

Part is used as pattern

The author, noting that conventional vacuum forming requires a master die which may be too costly to use for short run parts, used the part itself as the pattern. Consequently, he has made truly conformal molds of motors, transformers and printed circuits by vacuum forming a plastics film on the part.

According to Olyphant, the vacuum formed plastics mold has eliminated excess resin thickness (a common cause of resin cracking) and mold parting lines (the major source of air leaks and voids) in encapsulated electronic and electrical parts. He says vacuum forming permits the fabrication of a mold that is adaptable to changing designs and production rates.



***Mold of motor** is made by vacuum forming a plastics film on the part. The film completely surrounds and conforms to the motor, and extends above it to form a reservoir into which an encapsulating resin can be poured.*

Another advantage: a vacuum formed plastics mold permits economical and effective use of encapsulating resins.

What films can be used for making molds?

Olyphant says there are a considerable number of plastics films available in vacuum forming grades. However, the choice of films for making molds is limited by several considerations. For example, the film must:

1. Adhere or release well from the casting resin.
2. Resist softening by the resin.
3. Be capable of more than usual elongation without rupturing.
4. Be self-supporting if the film mold is to be used without support at the cure temperature.

The only films tested so far that have easy release are polypropylene and high density polyethylene. Polypropylene seems superior to high density polyethylene in drawing.

Camera Takes Close Look at Metal Fatigue

A close look at metal fatigue, solid-state behavior under high speed impact, shock waves and explosions can be obtained by using a new camera that takes pictures at speeds from 480 to 1,600,000 pictures per second.

The high speed camera is said to make it possible to stretch the events within a second into 28 hr, i.e., the events of 1 sec if projected at the standard rate of 16 frames per second would continue for 28 hrs.

The camera, marketed by Benson-Lehner Corp., Santa Monica, Calif., uses standard 35-mm film in black and white or color.

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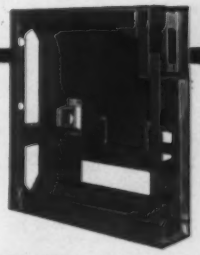
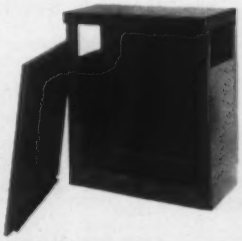


Welded Aluminum Electronic Chassis Assembly weighs 17 pounds. Overall dimensions, 23¾" x 20⅞" x 7⅞". 28 formed parts, 123 certified spot welds.



◀ **Welded Steel Electrical Cabinet Assembly** weighs 67 pounds. Dimensions, 25" x 14" x 30". 24 component parts. 24 tack welds, 36 spot welds, riveting and 6" of arc welding. Painted.

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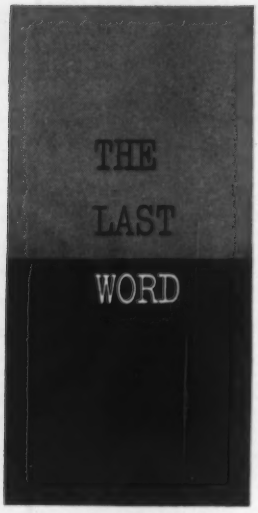
Are We Headed for a Technological Dark Age?



by ***H. R. Clauser***
Editor

A social scientist recently reported that the technical world will reach a peak of creativity in fifteen years and that this peak will be followed by a decline into a new dark age. Whether his prediction, which is based on a thorough historical analysis, will come to pass remains to be seen. But there are many prominent scientists and engineers who are concerned about the future of research and who fear that the decline in creative activity has already begun.

Young researchers are the key

The National Science Foundation's conference on "Research Goals" held late last year focused on one important facet of the creativity problem. The specific question posed was: "How can young research scientists and engineers be brought more stimulatively, imaginatively, and creatively into contact with the frontiers of science and technology in such a way as to accelerate significant discovery, both in the advancement of science and in the translation of science into new technology?"

As the conference made clear, there are many forces working against creativeness. In the broadest sense "the rigidities of (our) highly structured society have erected formidable barriers to . . . originality of thought." More specifically, the rigidity and conservatism of education and technical societies have tended to encourage small steps in the extension of knowledge and to discourage long leaps that lead to significant discovery.

Bold steps are needed

To overcome these forces that stifle creativity it will be necessary for our colleges and societies to first take bold and imaginative steps. Some of the many steps recommended by the conference were:

In the case of colleges—

1. Invite leading scientists to meet with students in order to promote infusion of ideas by personal association.

2. Encourage more venturesome attitudes in doctoral research and thus reduce the amount of "hole plugging" type of research.

3. Develop educational programs that require the student to exercise a high degree of originality.

In the case of technical societies—

1. Establish more effective practices to increase the participation of talented young members at meetings.

2. Encourage the presentation of papers of a philosophical nature which look to the future of science and technology.

3. Develop comprehensive programs for digesting the "state of the art."

4. Establish meetings that will more effectively result in cross-fertilization of ideas.

5. Establish free forums at engineering society meetings where any member can make a short presentation of his creative work, allowing the widest latitude of subject matter.

Nothing less will do

To take the above steps will require discarding many senile orthodoxies and outmoded traditions. We must replace them with fresh and more speculative approaches and with plans that are for the future rather than of the past. If we are to continue the upward surge of science and avoid a slide into a technological dark age, nothing less will do.

CELANESE MATERIALS REVIEW

- FORTIFLEX linear polyolefins
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- POLYESTER resins

Design and cost advantages spur demand for Celanese reinforced polyester resins

Whether your product is a button or a boat—big or small—a change to polyester reinforced plastics could boost your profits. Celanese polyesters offer equal or better strength and stiffness than the materials which you may now be using.

FROM RADIO CAPACITORS TO AUTO BODIES

Among the most versatile and economical of plastics, polyesters are especially effective for fabricating large, rigid shapes or small intricate parts. If you are designing machine housings, exhaust ducts, truck bodies, boats, tote boxes, or decorative items such as desk sets, trophy bases, lamp shades or buttons, it will pay you to investigate the economies and improvements made possible by polyester resins. Polyester resins, reinforced with glass, are among the strongest materials available today on a strength-to-weight ratio.

CELANESE OFFERS A SWEEP OF FORMULATIONS

Thirty-five formulations are available from Celanese. Check this listing of major types for an idea of their versatility:

General purpose resins
Flexible resins
Flame-resistant resins
Preform and premix molding resins
Casting resins
Marcothix high-viscosity resins
Light stable resins
Low exotherm resin
Fast cycle hand lay-up resins
Electrical resins
Auto body repair kit resins

VARIED PRODUCTION PROCESSES

With Celanese Polyester resins, production runs as well as item size can vary from large to small. Cure is effected by catalyst, without the need for heat or pressure. Products emerge with a high-gloss—sturdy, rigid, ready for use. Fabrication techniques include hand lay-up, spray-up, preform or premix molding, casting and vacuum bag molding.

LET CELANESE HELP YOU

The Celanese Technical Service and Application Laboratory offers experienced assistance in all phases of polyester applications. If you plan to make a product where polyesters may be suitable, a consultation with Celanese on costs, methods, formulations and key design factors can be valuable to you.

Celanese® Fortiflex® Forticel® Marco® Marcothix®

MAKE LARGE, RIGID SHELLS, PANELS, MOLDINGS OF CELANESE POLYESTERS

TANK TRUCK
BY MARCO METHOD

OFFICE FURNITURE
BY PREFORM

AUTOMOTIVE PARTS
BY PREMIX MOLDING

BOAT HULL BY SPRAY-UP
OR HAND LAY-UP

SEND FOR NEW POLYESTER BROCHURE

File-sized folder gives detailed descriptions of Celanese Polyester resin formulations. Physical properties, handling procedures and processing methods are fully described.

Celanese
PLASTICS and RESINS

For more information, turn to Reader Service card, circle No. 484

CELANESE PLASTICS COMPANY, a Division of Celanese Corporation of America, Dept. 102-F, 744 Broad St., Newark 2, N. J.
In Canada: Canadian Chemical Company, Limited, Montreal, Toronto, Vancouver
Export Sales: Amcel Co., Inc., and Pam Amcel Co., Inc., 180 Madison Ave., N. Y. 16

☐ Please send Bulletin M2A, "Celanese Polyester Resins"
☐ Please contact me regarding Celanese Technical Service

Name _____
Title _____ Company _____
Address _____

How steel tubing saves weight in helicopter...in budget, too

Shown below is the main rotor shaft of a new model helicopter. Because it was hollowed out of solid steel bars to save weight, it was costly to make. After machining to thousandths of an inch accuracy, previously undetected steel flaws showed up. One out of every five parts had to be rejected.

Timken Company Metallurgists were consulted. After careful study, they recommended a special analysis of Timken® seamless steel tubing. Savings began immediately. Because the hole was already there, no drilling was required. Steel was saved. And with the extra advantage of uniform forged quality in Timken seamless tubing, rejects of finished parts were practically nil.

Let us help you cut your costs, get better quality finished products. Our engineers will recommend the most economical tube size for your hollow parts jobs, one guaranteed to clean up to your finish dimensions. ***When you buy Timken steel you get...*** *1) Quality that's uniform from heat to heat, bar to bar, order to order. 2) Personal attention from the experts in specialty steels. 3) Over 40 years experience in solving tough steel problems.* The Timken Roller Bearing Company, Steel and Tube Division, Canton 6, Ohio. Cable: "TIMROSCO". *Makers of Tapered Roller Bearings, Fine Alloy Steel and Removable Rock Bits.*

TIMKEN ALLOY STEEL AND SEAMLESS STEEL TUBING ARE AVAILABLE FROM STEEL SERVICE CENTERS IN 44 CITIES IN THE UNITED STATES

For more information, turn to Reader Service card, circle No. 406